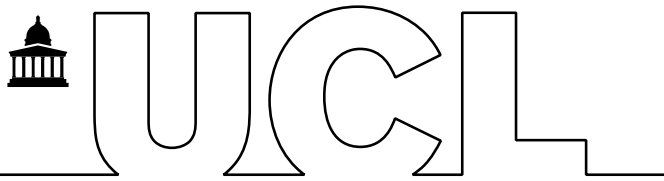

The association between social support and weight outcomes in the general population and in bariatric surgery patients

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I, Urszula Tymoszuk, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature …….. Date …….....

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Abstract

To date, little attention has been paid to supportive relationships as factors contributing to body weight in the general population and bariatric surgery outcome, as well as to theoretical frameworks conceptualising these associations. Studies presented here follow the well-established practice of examining functional and structural aspects of social support within the Stress Buffering and Main Effect frameworks.

Although the associations between social support and body mass index (BMI) and waist-to-hip ratio (WHR) have been found at different time points during adult life, it is currently unknown if person-level trajectories of BMI and WHR over midlife vary by social support. This question was addressed using data from a large occupational cohort, the Whitehall II study.

Supportive relationships could also facilitate the adjustment to lifestyle changes required post-bariatric surgery and hence promote weight loss. To test this association, 189 patients were recruited to the study pre-surgery at University College London Hospital Bariatric Centre for Weight Management and Metabolic Surgery. Upon recruitment, patients completed a questionnaire on their social support. Body weight was measured once before and three times after the surgery.

The key findings are: the emotional dimension of support in both populations (particularly emotional support provided to others in the clinical population), being married in men in the general population and greater contact with friends in the clinical population are related to maintaining healthy body weight over midlife as well as promoting weight loss from bariatric surgery. Health behaviours, common mental disorder, self-esteem and mastery did not explain these associations. If replicated in more representative samples and using repeated social support measures, these findings could inform intervention studies and clinical practice. Further research on emotional social support, particularly given to others and revised conceptual models linking various social support aspects to body weight are warranted.

Introduction

People who are interdependent, who mutually influence each other's feelings, thoughts and behaviours and who care for each other are believed to form a close social relationship (Clark, Aragon and Hirsch, 2015, p.563). Social support is an important aspect of close social relationships. Social support is often defined as helpful and caring interactions between people as well as a mere presence of a close relationship. The evidence accumulated over 35 years shows that greater social support is associated with health and longevity, while inadequately supportive relationships are linked with mortality and morbidity (Berkman and Syme, 1979; Cohen and Wills, 1985; House, Landis and Umberson, 1988; Cohen, 2004; Uchino et al., 2001; Holt-Lunstad, Smith and Layton, 2010). The association between close social relationships and body weight has been increasingly recognised particularly since the seminal study by Christakis and Fowler (2007) which suggested that obesity is "socially contagious". Using repeated data on 12,067 participants examined between 1971 and 2003 Christakis and Fowler found that the risk of obesity was associated with degrees of social closeness. The first degree of separation (knowing personally an obese person, ego-alter) was associated with 45% increased risk of obesity, the second (ego-alter's alter) with 20% increased risk and the third (ego-alter's-alter's alter) with 10% increased risk. This study has sparked a lot of interest in the role of social relationships in the aetiology and prevention of obesity. However, a decade of research later, many gaps in the association between supportive relationships and body weight remain.

Body mass index (BMI) and waist-to-hip ratio (WHR) are important and well-studied predictors of health outcomes in middle-aged and older adults (Hughes et al., 2004; Snijder et al., 2006; Zhang et al., 2008; Pischon et al., 2008; Huxley et al., 2010; Seidell, 2010). Research shows that body weight and BMI increases in the first 70 years of lifetime and then decreases (Kahng, Dunkle and Jackson, 2004; McDowell et al., 2008; Barone et al., 2006). Maintaining stable body weight/BMI over time has been linked to lower mortality (Bamia et al., 2010; Lee et al., 2011; Zheng, Tumin and Qian, 2013; Zajacova and Ailshire, 2014), while weight loss in old age has been linked in the majority of studies to higher mortality (Myrskylä and Chang, 2009; Newman et al., 2001; Barone et al., 2006; Wannamethee, Shaper and Lennon, 2005). These body weight changes have been predominantly studied as exposures rather than outcomes of interest and only few longitudinal studies examined BMI trajectories over the transition from midlife to old age, and the majority of these studies are based one cohort, the Health and Retirement Study. These few longitudinal studies assess the

contribution of demographic, socioeconomic and behavioural factors to BMI levels and rate of change (Clarke et al., 2009; Hulmán et al., 2014; Jacobsen et al., 2001; He and Baker, 2004; Dugravot et al., 2010; Botoseneanu and Liang, 2012), however close social relationships have been relatively overlooked as direct and indirect factors affecting body weight trajectories. Supportive and unsupportive social relationships have been associated with BMI and WHR levels at various adult ages (Wing et al., 1991; Kaye et al., 1993; Ravaja, Keltikangas-Järvinen and Viikari, 1998; Räikkönen, Matthews and Kuller, 1999; Ali and Lindström, 2006; Kouvonen et al., 2011; Croezen et al., 2012; Oliveira et al., 2013; Kershaw et al., 2014) as well as with more beneficial health behaviours such as non-smoking, fruit and vegetable consumption and vigorous physical activity (Poortinga, 2006; Harvey and Alexander, 2012; Allgöwer, Wardle and Steptoe, 2001; Tamers et al., 2013; Umberson, 1992). No previous studies have tested the association between various aspects of social support and person-level BMI/WHR trajectories over midlife to old age.

Whilst gradual increases in body weight are the norm in the general population, high prevalence of obesity (BMI >30 kg/m^2) is also increasingly common in the population. WHO estimates that more than 1.3 billion adults are overweight and 600 million adults are obese, and that these numbers are rising (WHO 2015; Finucane et al., 2011; Singh et al., 2016). In the UK, 41% of men and 31% of women were overweight and further 24% of men and 27% of women were obese (2% of men and 4% of women were severely obese BMI ≥40kg/m^2) in 2014 (Scantlebury and Moody, 2014). Combing both central and general obesity prevalence indicates that 34% of men and 43% of women in the UK are at high or very high risk of obesity-related chronic disease (Scantlebury and Moody, 2014). It has been estimated that in 2003/2004 overweight and obesity accounted for 7.3% of deaths and morbidities in UK and over 66,000 deaths could have been prevented if all adults had a healthy BMI of 21 kg/m^2 (Allender and Rayner, 2007). Excessive fat tissue raises the risk of type 2 diabetes, cardiovascular disease, certain cancers, hypertension, dyslipidaemia, osteoarthritis, liver dysfunction, gall-bladder disease, asthma, sleep apnoea and reproductive disorders (Guh et al., 2009; Arnold et al., 2014; Khaodhiar, McCowen and Blackburn, 1999). Obese individuals, particularly obese women, suffer also from poorer psychosocial functioning, depression, anxiety, and lower quality of life (de Wit et al., 2010; Scott et al., 2008; Yan et al., 2004; Kolotkin, Meter and Williams, 2001; Jagielski et al., 2014; Puhl and Heuer, 2009; Nelbom et al., 2010). Among other harmful consequences of obesity are the economic concerns, such as the healthcare costs of treating obesity and its comorbidities as well as absence from work. According to the Foresight report in 2007 obesity has cost the NHS £4.2 billion and the total

cost to the UK economy approximated £15.8 billion; these costs are projected to rise to £9.7 billion NHS costs and £49.9 billion total costs in 2050 (MacPherson, Marsh and Brown, 2007).

Obesity can be treated and there are various non-surgical and surgical (metabolic/bariatric surgery) treatment options. Bariatric surgery is currently considered the most effective treatment for short and long-term weight loss in people with severe obesity (BMI of 40 or more) resulting in between an average weight loss of 26 kg (95% confidence interval −31 to −21) and 38.5 kg (−40.4 kg, −36.6 kg) (Gloy et al., 2013; Buchwald et al., 2009; Sjöström et al., 2004; Maggard, 2005; Picot et al., 2009; Colquitt et al., 2014). Bariatric surgery leads also to significant health improvements such as reduction or resolution of type 2 diabetes, hypertension, hyperlipidaemia, non-alcoholic fatty liver and obstructive sleep apnoea disease as well as decreased mortality rate, lower risk of cardiovascular disease, malignancies, endocrine disorders, respiratory and infectious disorders compared to morbidly obese controls who are not treated surgically (Buchwald et al., 2004; Christou et al., 2004; Wolfe, Kvach and Eckel, 2016; Douglas et al., 2015). Bariatric surgery appears to also have a beneficial impact on psychological wellbeing, depression, anxiety, perceived stress, sexual satisfaction, quality of life and employment opportunities (Karlsson, Sjöström and Sullivan, 1998; Schauer et al., 2000; Herpertz et al., 2003; Ray et al., 2003; Miranda et al., 2013; Hachem and Brennan, 2016; Thonney et al., 2010; Wolfe, Kvach and Eckel, 2016). The beneficial effects of the surgery led to a significant increase in the number of procedures performed worldwide, from 146,301 operations reported in 2003 to 468,609 operations reported in 2013 (Angrisani et al., 2015; Buchwald and Oien, 2013).

Despite the vast amount of evidence on the health benefits of supportive relationships in the general population, social relationships of bariatric surgery patients have been rarely considered and hardly ever a primary focus of studies examining post-operative weight loss. Supportive close relationships could help the patients to adjust to lifestyle changes during the early months post-surgery such as adherence to new eating patterns, physical activity regimens as well as post-surgery clinical appointments. As a result, patients' social support system could play an important role in short and long term weight loss.

The studies presented in this thesis test the associations between various aspects of social support and weight gain or weight loss in the general and clinical populations. Chapter 1 of this thesis, defines social support, its various aspects and measurements such as the distinctions between functional and structural support and between received and provided

support. It further describes body weight measures and the significance of examining body weight trajectories over time. Lastly, chapter 1 introduces bariatric surgery, its mechanism of action, two main procedures and weight loss metrics. Chapter 2 reviews previous evidence on the association between social support and weight gain in the general population and the association between social support and weight loss in bariatric surgery patients. Chapter 2 also describes previous theoretical models and explanatory pathways linking social support to weight outcomes as well as potential confounding factors to consider in these associations. Chapter 3 summarises the gaps in previous studies and outlines the aims and objectives of the thesis. It also presents the conceptual model guiding the analyses of this thesis. Chapter 4 describes the Whitehall II cohort study population which was used to test the association between social support and weight gain, as well as the methodology used in these analyses. Chapter 5 presents the results from both cross-sectional and longitudinal analyses in the Whitehall II study as well as their interpretation. Chapter 6 describes the bariatric surgery patients' population, the process of data collection, the social support questionnaire administered to patients as well as the methodology used to analyse patient data. Chapter 7 presents the results from the descriptive and main analyses of the association in bariatric surgery patients as well as the discussion of the results. Chapter 8 is the overall discussion of results from both populations. It summarises the main findings and contributions, critiques the conceptual model used for the present studies and suggests alternative explanatory mechanisms behind the association between social support and weight outcomes. Chapter 8 also describes the limitations and strengths of the analyses presented in the thesis.

Chapter 1 Definitions and measurements of social support and weight outcomes

This chapter defines social support, distinctions between functional and structural aspects as well as received and provided social support to others. It describes the association between social support and health outcomes, pathways which potentially mediate these associations and factors that may moderate these associations, notably gender. This chapter further describes body weight outcomes and the importance of studying body weight trajectories over time. Lastly, the chapter explains bariatric surgery procedures and weight loss metrics.

1.1 Functional and structural aspects of social support

1.1.1 Dominant definitions of social support

Close relationships exist between interdependent people who mutually influence each other's feelings, thoughts and behaviours as well as care for each other's wellbeing (Clark, Aragon and Hirsch, 2015, p.563). Social support is believed to characterise close relationships and is often understood as both presence of close relationships and supportive interactions (expressions of understanding, responsiveness and caring) between close persons. Supportive interactions can further refer to perceptions of availability and adequacy of social support as well as an actual received aid and help (Barrera, 1986; Lakey and Cohen, 2000). As a result, social support is a multifaceted concept and has been inconsistently defined across previous studies (Lakey and Cohen, 2000; Cohen, Underwood and Gottlieb, 2000; Cohen, 2004; Barrera, 1986; Gottlieb and Bergen, 2010). A commonly used method of conceptual organising of social support terms separates them into function (quality) and structure (quantity) of the support system. Functional social support refers to various exchanges or transactions between individuals, while structural social support describes objective characteristics of the social network – most commonly an existence and number of social connections with whom one could or does engage in supportive transactions (Taylor, 2007).

Functional social support has been frequently divided into subtypes such as: e*motional* or *confiding support* which provides compassion, approval, trust, care and allows expression of feelings or concerns; *instrumental support* or *practical*/*tangible support* which serves a

function of facilitating solving practical problems, delivers tangible aid and assistance such as financial help or assistance with transportation or childcare; *informational support* which refers to suggestions or guidance aiming at improving effectiveness of coping, awareness of resources and generation of alternative options; as well as other types of support indirectly relating to emotional support domain such as *belonging support*, *appraisal* or *validation support* which provide companionship, affirmation and social comparison (Langford et al., 1997; Wills and Shinar, 2000). In fact, previous research suggests that emotional support and perceived closeness are a central dimension of supportive exchanges (Krause and Markides, 1990; Poulin et al., 2010; Morelli et al., 2015). Although studies of supportive relationships often accent the positive aspects, received social support does not always meet the needs of the support receiver and close relationships can also be a source of problems, conflict, burden and cost (Rook, 1984). Negative aspects of social support have been commonly defined as experiences of excessive demands and criticism and feelings of disappointment and annoyance associated with close relationships (Schuster, Kessler and Aseltine, 1990). Negative interactions and poor relationship quality have been correspondingly an important part of studies investigating functional aspects of social support (Schuster, Kessler and Aseltine, 1990; Krause, 1995; Birditt, Jackey and Antonucci, 2009).

Structural aspects of social support usually refer to characteristics and number of supportive social ties as well as frequency of social contact (Lakey and Cohen, 2000; Berkman et al., 2000). Marriage has been often used as a measure of structural support in adults, as it is an important and distinctive source of social support and spouses or partners tend to be the main providers of support (Walen and Lachman, 2000). There is also substantial evidence suggesting that in married couples not having spousal support and not considering the spouse as the main source of support is particularly detrimental (See Barger and Cribbet, 2016). It is important to acknowledge that the research defining marriage as structural social support was conducted at the time when marital unions were a dominant norm, while the alternatives to marriage such as civil unions and domestic partnerships between people of same or different gender were less common (Cherlin, 2004). Hence, the majority of previously published studies and those reviewed in this thesis focus on marital unions. However, regardless of the type of union or partnership, the underlying rationale of including relationship status as a structural social support, is that it signifies a presence of a special, romantic relationship, which depending on its quality, serves to provide intimacy and stability (Sassler, 2010). Another routinely used measure is the size of the social network – i.e. number of friends and family members as well as frequency of social contact with them (Krause, 1999;

Sherbourne and Stewart, 1991). Structural measures aim to quantify one's close social ties and social contact in order to objectively assess access to and number of opportunities for supportive interactions.

This thesis will focus on quality and quantity aspects of social support. It is important to recognise however that different aspects of social support and social relationships separated for research purposes, are inevitably mutually influential in real life as daily supportive interactions occurring between people take place within social networks and simultaneously shape them. Conflict can lead to an end of a relationship and a significant change in social network, while an unexpected supportive exchange with a stranger may lead to new social ties. Furthermore, loss of a relationship and feelings of loneliness are often a "driving force" for seeking new relationships (Clark, Aragon and Hirsch, 2015). However, to date the interplay between different aspects of social relationships has been hardly empirically studied.

1.1.2 Linking supportive relationships to health

Over 35 years of mostly observational evidence show that supportive relationships are associated with health and longevity, while inadequately supportive relationships are linked with mortality and morbidity (Berkman and Syme, 1979; Cohen and Wills, 1985; House, Landis and Umberson, 1988; Cohen, 2004; Uchino et al., 2001; Holt-Lunstad, Smith and Layton, 2010). Supportive interactions have been associated with, among others: lower all-cause mortality (Holt-Lunstad, Smith and Layton, 2010), cardiovascular mortality (Lett et al., 2005; Orth-Gomér, Rosengren and Wilhelmsen, 1993; Berkman, Leo-Summers and Horwitz, 1992), cancer mortality (Kroenke et al., 2006; Ikeda et al., 2013), better mental health (Stansfeld, Fuhrer and Shipley, 1998; Uchino et al., 2001; Fiori, Antonucci and Cortina, 2006; Croezen et al., 2012) and better cognitive function (Seeman et al., 2001; Gow et al., 2013). Unsupportive exchanges with close persons have been linked to heart disease (De Vogli, Chandola and Marmot, 2007) depression (Schuster, Kessler and Aseltine, 1990; Stafford et al., 2011), cognitive decline (Liao et al., 2014) and increasing body mass (Kouvonen et al., 2011; Kershaw et al., 2014).

Both quality and quantity aspects of social support have been repeatedly demonstrated as important for wellbeing and health (Pinquart and Sörensen, 2000; Thomas, 2010; Holt-Lunstad, Smith and Layton, 2010). Marriage and marital relationship quality, for instance, have been consistently positively linked with physical and psychological wellbeing in previous

research (Kiecolt-Glaser and Newton, 2001; Robles and Kiecolt-Glaser, 2003; Waite, 1995; Robles et al., 2014; Slatcher and Schoebi, 2017) and married people have been consistently shown to have lower mortality rates since as early as 1858 (Farr, 1858; Rogers, 1995; Lillard and Waite, 1995; Hemström, 1996; Manzoli et al., 2007; Johnson et al., 2000; Shor et al., 2012). Composite social relationships measures, including both quality and quantity components, show the strongest effect sizes for mortality – indicating that functional and structural elements of social relationships are both important for health (Holt-Lunstad, Smith and Layton, 2010).

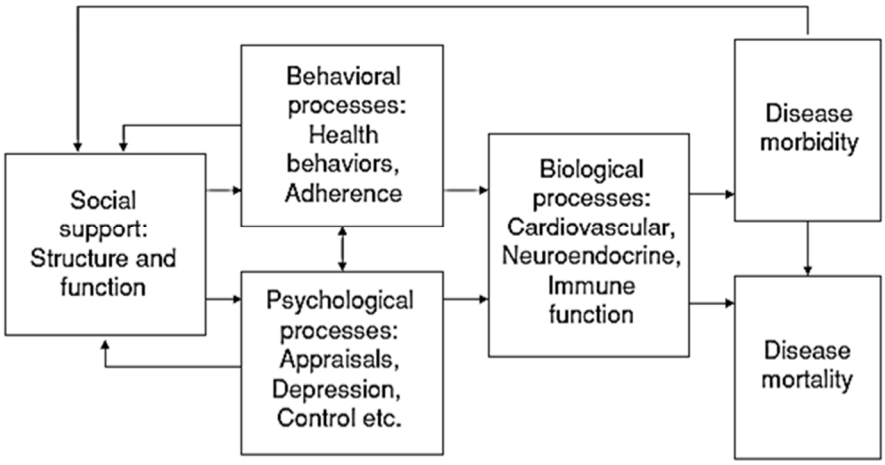
There are two main theoretical models describing the effects of social support on health: the stress buffering and the main effect hypotheses (Cohen and Wills, 1985; Cohen, Underwood and Gottlieb, 2000; Cohen, 2004). Within a long, dominant tradition defining social support as a "purposive action" (Schlecker, 2013, p.1), the stress buffering framework proposes that social support benefits health as the provision of social support to a distressed individual buffers harmful health effects of stress (Cohen and Wills, 1985; Cohen, Underwood and Gottlieb, 2000). Believing that resources are available as well as receiving actual help can affect appraisals of the stressful situation and coping with it; and as a result may influence psychological, physiological and behavioural reaction to the stressor (Cohen, Underwood and Gottlieb, 2000). Indeed, many experimental studies have shown that the presence of a close, familiar person during an acute stress test is linked to a lower physiological reactivity (Uchino et al., 2012) and there is good evidence suggesting that the presence of others can in itself diminish the negative affect in stressful situations (Zaki and Williams, 2013). Some argue however that the natural instinct among social animals to desire and seek affiliation and social contact under threat is merely a part of interpersonal regulation mechanisms (i.e. "modulation" as part of greater "regulation"; Zaki and Williams, 2013).

The main effect framework suggests that social support has a direct effect on health that is not restricted to stressful situations, for example having multiple close social ties, i.e. structural aspects of social support on their own are able to benefit individual's health (Cohen and Wills, 1985; Lakey and Cohen, 2000; Cohen, 2004; Taylor, 2007; Lakey and Orehek, 2011). Having multiple sources of social support increases access to various beneficial resources which could be utilised to benefit health awareness, prevent illness or provide informal care (Cohen, Underwood and Gottlieb, 2000). Having a close relationship and participating in a social network also exposes an individual to social norms, social comparison, and social influences, which can affect her beliefs and behaviours. For example, individuals in a given network might aspire to a certain body image and share norms on health behaviours such as

overeating, smoking, heavy alcohol consumption, dieting, exercising (Umberson, Crosnoe and Reczek, 2010; Berkman et al., 2000; Thoits, 2011; Cunningham et al., 2012; Powell et al., 2015). Furthermore, social influence can take an active role of social control and peer-pressure whereby group members openly encourage or discourage certain behaviours and attitudes (Thoits, 2011; Craddock et al., 2015). A large number of studies on marital status and health indicate social control as an important mechanism of both positive and negative influence on spouses' health practices (Umberson, 1992; Lewis and Butterfield, 2007; Novak and Webster, 2011; Tucker and Anders, 2001). Having close, supportive relationships may foster individuals' identity, sense of purpose, meaning of life and self-esteem by providing belonging, meaningful social roles and stability (Cohen and Wills, 1985; Lakey and Cohen, 2000; Cohen, 2004; Taylor, 2007; Thoits, 2011). Lastly, "Relational Regular Theory" by Lakey and Orehek (2011) proposed that the main effect of support operates via close persons regulating each other's affect, beliefs and behaviour through sharing ordinary activities and conservations, instead of conversations about ways to deal with stress.

Both theoretical models suggest that the beneficial effect of social support on physical and mental health operates through various behavioural, physiological, and psychological pathways (Cohen, Underwood and Gottlieb, 2000; Berkman et al., 2000; Uchino, 2006, 2009a; Reblin and Uchino, 2008; Thoits, 2011; Figure 1). There is indeed good evidence linking greater support to health-promoting behaviours, beneficial cardiovascular, neuroendocrine and immune functions, greater self-esteem and self-efficacy or mastery, and lower perceived stress and affective symptoms (Berkman et al., 2000; Uchino, 2006; Umberson, Crosnoe and Reczek, 2010; Reblin and Uchino, 2008; Thoits, 2011; Langford et al., 1997).

Figure 1 Pathways linking social support to health from Uchino 2006



1.1.3 Providing social support and health benefits

Although certain conceptualisations of social support state that social support is "[...] an exchange of resources between at least two individuals [...]" (Shumaker and Brownell, 1984, p.13) and thus acknowledge not only the recipient but also the provider of social support, functional social support is rarely conceptualised as social support provided *to others*. In fact, some suggest that the unaccounted provided social support might have been responsible for health benefits found in previous studies of received social support (Poulin et al., 2013; Inagaki and Eisenberger, 2016; Brown and Brown, 2015). Indeed, studies which have included provided and received social support in their analyses show that providing support to others is more salient for health than receiving support (Brown et al., 2003; Thomas, 2010; Warner et al., 2010; Inagaki et al., 2016). Providing support to others has been associated with: lower mortality in older adults controlling for a wide range of demographic, socioeconomic, health behaviour, mental health and personality characteristics (Brown et al., 2003; Gruenewald, Liao and Seeman, 2012), lower odds of increases in activities of daily living disability (Loucks et al., 2006), reduced cardiovascular activity such as systolic and diastolic blood pressure and heart rate (Piferi and Lawler, 2006; Inagaki and Eisenberger, 2016), lower perceived stress and biomarkers of stress related to sympathetic nervous system activation such as salivary alpha-amylase (Inagaki and Eisenberger, 2016; Piferi and Lawler, 2006; Inagaki et al., 2016), lower depression (Schwartz and Sendor, 1999; Piferi and Lawler, 2006; Oman, Thoresen and Mcmahon, 1999) and improved wellbeing (Thomas, 2010; Morelli et al., 2015; Krause, Herzog and Baker, 1992) and these benefits are seen across different cultures which vary in wellbeing and social support provision levels (Novin, Tso and Konrath, 2014). Providing social support has been also associated with feelings of increased social closeness and connection, for example giving support to a distressed partner compared with physical touch without giving support was associated with higher feelings of closeness with the partner (Inagaki and Eisenberger, 2012). Providing social support to others could also indicate greater probability of receiving support oneself when in need (Krause, Herzog and Baker, 1992) and indeed many previous studies report a moderate to strong correlation between receiving and giving social support (Brown et al., 2003; Piferi and Lawler, 2006; Liang, Krause and Bennett, 2001). Providing social support has been associated with an increase in feelings of self-worth, self-esteem, self-compassion and personal control (Schwartz and Sendor, 1999; Krause, Herzog and Baker, 1992; Krause and Shaw, 2000; Krause, 2016; Breines and Chen, 2013). Previous studies report indirect associations between providing social support and various health outcomes such as cardiovascular health (Piferi and Lawler, 2006), quality of life (Warner et

al., 2010), psychological distress (Krause, Herzog and Baker, 1992) and self-rated health (Krause, 2016) mediated through self-efficacy, perceived control and self-esteem or self-worth. Stronger self-esteem could be linked with greater respect and value for one's life and translate into taking better care of oneself as well as more positive affect (Krause, 2016). Both higher self-worth and greater perceived control and mastery are likely to enhance coping ability, positively influence the appraisal of stressors and diminish physiological stress response (Krause, 2016; Roepke and Grant, 2011). Mastery might also affect engagement and adherence to health-promoting behaviours and practices (Roepke and Grant, 2011).

One exception to health benefits of giving support to others has been chronic caregiving, however previous studies of caregivers have often failed to take into account the emotional suffering of caregivers associated with experiencing the worsening of health and death of loved ones (Poulin et al., 2010). There is evidence to suggest that, when the provision of support involved in caregiving is closely examined, the number of hours spent in giving care is associated with a greater positive affect, particularly when a couple's perceived interdependence is high (Poulin et al., 2010; Brown and Brown, 2014).

Novel neuroimaging studies of providing social support suggest that the health benefits of giving social support follow the same mechanisms as maternal caregiving (Eisenberger, 2013; Brown and Brown, 2015; Inagaki and Eisenberger, 2012, 2016). Studies of altruistic behaviour in people have further suggested that humans are naturally "hardwired" to nurture and care for others, particularly for infants and children (Eisenberger, 2013; Inagaki and Eisenberger, 2016). Maternal caregiving behaviour has been found to be associated with greater brain activity in the ventral striatum, septal area and amygdala, which are brain regions involved in processing basic rewards and involved in fear and threat response (Inagaki and Eisenberger, 2012; Inagaki et al., 2016). Previous studies show that providing support to the loved one in need, was associated with greater activity in the ventral striatum and septal area as well as lower activity in the amygdala compared with arm holding without a need for support (Inagaki and Eisenberger, 2012; Inagaki et al., 2016). Thus, giving support to others, both in men and women, is associated with activation in reward related brain regions and inhibition in the regions associated with threat and stress perception (Inagaki et al., 2016; Eisenberger, 2013). Furthermore, activity in these regions in response to caregiving appears to be interconnected. Activity in the reward region (septal area) during provision of support was negatively associated with activity in the fear region (amygdala), suggesting that caregiving could independently decrease stress response and benefit health (Eisenberger,

2013; Inagaki et al., 2016). Experimental neuroimaging studies of received social support (such as hand holding or seeing pictures of close persons while experiencing pain) also indicate that received social support is associated with decreased activity in regions involved in responding to pain and threat such as periaqueductal gray as well as increased activity in regions related to safety and reward, such as the ventromedial prefrontal cortex (Eisenberger, 2013). However, a recent study assessing self-reported received and provided social support demonstrated that although both types of support were negatively associated with a psychological index comprised of depression, perceived stress, perceived social rejection and loneliness scales, only self-reported giving social support was associated with more positive effects "at the level of the brain", such as higher activity in the reward region and lower in the threat regions (Inagaki et al., 2016).

1.1.4 Important gender differences in social support

Differences in socialisation between men and women, i.e. masculinity and femininity standards and gender roles have important implications for social support (Reevy and Maslach, 2001; Samter, 2002; Jensen, Rauer and Volling, 2013). Previous studies have shown that women are more likely to provide social support unprompted and at request, provide more sensitive support and score higher on comforting skills (Reevy and Maslach, 2001; Samter, 2002; Jensen, Rauer and Volling, 2013). Women are also more likely than men to seek social support as a means of coping as well as to seek and receive support from several sources of support, particularly other women (Taylor, 2007; Tamres, Janicki and Helgeson, 2002; Samter, 2002; Reevy and Maslach, 2001). Men tend to obtain most of the support from one, closest person, for married men it is usually their spouse (Fuhrer et al., 1999; Fuhrer and Stansfeld, 2002). Married women however are less likely than married men to consider their spouse as the closest person and primary source of support and social control, although the spouse or partner is the most frequently nominated closest person for both genders (Fuhrer et al., 1999; Fuhrer and Stansfeld, 2002; Umberson, 1992).

There is some evidence showing that women might be more likely to benefit from social support (Schuster, Kessler and Aseltine, 1990; Schwarzer and Leppin, 1989), for instance a meta-analysis showed that the correlation between social support and health was stronger in women than in men (Schwarzer and Leppin, 1989). Positive and negative relationships with family members were also more likely to be associated with depression in women, but not in men (Schuster, Kessler and Aseltine, 1990). However, other studies report benefits of

social support on mental wellbeing in men and not women (Stansfeld, Fuhrer and Shipley, 1998) and many studies, particularly early ones, suggests that men might benefit from being married more than women do, as well as suffer more harmful consequences of marital dissolution (Williams and Umberson, 2004; Rogers, 1995; Hemström, 1996; Lillard and Waite, 1995; Shor et al., 2012). Yet not all studies find this gender difference (Manzoli et al., 2007) and others report that progressing age diminishes the difference between men and women in health benefits associated with marriage (Shor et al., 2012). There are also suggestions that the health benefits of marriage over non-marriage have decreased for men over the past three decades (Liu and Umberson, 2008). The moderating effect of gender on the association between social support and health outcomes remains largely inconclusive.

Summary

Functional and structural support such as received support and marriage are well-established factors affecting adult health. Received social support has been paid much attention in previous research; however, to gain a fuller understanding of ways through which social support affects health, it is important to also consider the effects of giving social support to others. Gender difference in the association between social support and health has often been discussed, yet empirical studies do not offer conclusive results. Despite good evidence on the association between functional and structural aspects of social support and health outcomes, such as all-cause mortality or cardiovascular health, little is known about their association with weight outcomes. Section 1.2, describes the main health outcome of this thesis: body weight. It summarises measurement methods of excessive weight, obesity-related health risks as well as changes in body weight associated with ageing. The following section 1.3 introduces bariatric surgery (metabolic and obesity surgery) currently the most effective severe obesity treatment. It describes benefits of bariatric surgery and methods of measuring weight loss from surgery.

1.2 Body weight, weight gain and weight loss

1.2.1 Definitions, measurements and risk factors associated with body weight levels

Excessive body weight or fat accumulation is caused by the imbalance between energy intake and expenditure. It is usually measured by body mass index (BMI) that is weight-to-height index (kg/m^2), waist circumference (WC) or waist-to-hip ratio (WHR). Both general obesity,

expressed by BMI ≥30 kg/m^2 and abdominal obesity measured by WC (≥102cm for men and ≥88cm for women) and WHR (≥0.95 for men and ≥0.80 for women) have been found to multiply the risk of mortality and morbidity of all causes, after adjusting for known confounders such as age, education, smoking, type 2 diabetes, systolic blood pressure and cholesterol level (Hu et al., 2005; Folsom et al., 2000; Koster et al., 2008; Pischon et al., 2008; Zhang et al., 2008; Ng et al., 2016). The attempts to determine which measure of adiposity is the most salient for disease and mortality have not reached a consensus (Huxley et al., 2010). Some studies suggest that abdominal and general obesity are both good predictors of type 2 diabetes, hypertension, dyslipidaemia and cardiovascular outcomes (Vazquez et al., 2007; Huxley et al., 2010; Seidell, 2010) and might be particularly informative when mutually adjusted in order to better assess body fat distribution and body shape (Pischon et al., 2008; Snijder et al., 2006). Others suggest that measures of central adiposity (WC and WHR) are stronger predictors of all-cause mortality than BMI (Seidell, 2010; Zhang et al., 2008). The inconsistencies could be due to differences in gender and ethnic group distributions in study populations (Zhang et al., 2008) and additionally complicated by changes in body weight and composition that occur with ageing (Woo, Ho and Sham, 2001; Hughes et al., 2004; Kuk et al., 2009).

1.2.2 Importance of understanding body weight trajectories from midlife to old age

Body weight changes with ageing with consequences for health, thus better understanding of body weight trajectories over middle and old age presents an opportunity to prevent disease and promote healthy ageing (Kuk et al., 2009). It is well-established that for the majority of people body weight increases steadily over middle age until around age 65, after which it declines (Jacobsen et al., 2001; Barone et al., 2006; Clarke et al., 2009; Dugravot et al., 2010; Botoseneanu and Liang, 2011; Kahng, Dunkle and Jackson, 2004). Longitudinal examinations of body weight trends and changes show that maintaining stable body weight over time has been linked to lower mortality (Bamia et al., 2010; Lee et al., 2011; Zheng, Tumin and Qian, 2013; Zajacova and Ailshire, 2014), while body weight loss in older age has been linked in a majority of studies to higher mortality (Myrskylä and Chang, 2009; Newman et al., 2001; Barone et al., 2006; Locher et al., 2007; Wannamethee, Shaper and Lennon, 2005).

Longitudinal data allows researchers to investigate person-level body weight trajectories. These indicate: the initial status of person's trajectory, i.e. initial body weight; as well as the

rate of the trajectory, i.e. curve of body weight growth (Chou, Bentler and Pentz, 1998). Body weight trajectory thus provides important health-relevant information as they allow the researcher to assess the determinants and consequences of increases and decreases in weight, as well as levels of weight. Many studies of different populations – for example analyses of 3,541 Norwegian men and 4,993 women, 4,869 Japanese adults and 10,314 US Health and Retirement study participants – reported that person-level body weight and BMI trajectories show a progressive increase until around age 65 followed by a decrease or flattening out of the trajectory (Barone et al., 2006; Jacobsen et al., 2001; Botoseneanu and Liang, 2011, 2012; Murayama et al., 2016). Some of these studies found that adjusting for mortality and birth cohorts explained the decline in body weight in those aged 65 years and older (Jacobsen et al., 2001; Botoseneanu and Liang, 2011), however it is possible that their follow-up was not long enough to include a sufficiently large sample of older adults.

Person-level body weight trajectories have been most commonly studied using BMI despite its limitations as a body composition indicator. BMI's accuracy as a proxy of body composition might change with age, as previous studies reported that in older adults abdominal adiposity can increase together with a decrease in BMI (Kuk et al., 2009) and waist circumference is a strong predictor of all-cause mortality independent of BMI (Bigaard et al., 2003). Other studies have also shown that WHR is a superior measure of visceral fat and total fat levels in ageing populations compared with BMI (Hughes et al., 2004; Kuk et al., 2009). WHR trajectories thus could be more accurate at capturing changes in metabolically active visceral fat and in body shape.

1.3 Treatment of severe obesity with bariatric surgery

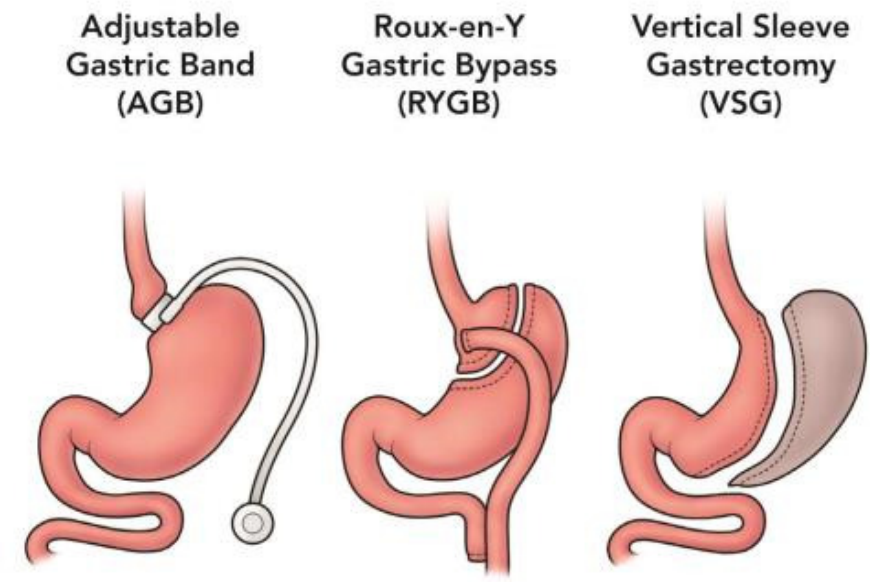
1.3.1 Bariatric procedures and their mechanisms of action

Metabolic or bariatric surgery is a surgical treatment of severe obesity. Current guidelines on eligibility for bariatric surgery by the National Institute for Health and Care Excellence state that individuals with a BMI of ≥40 kg/m^2 or a BMI of ≥35 kg/m^2 with a co-morbid condition (such as type 2 diabetes or high blood pressure) who have repeatedly been unable to achieve weight loss through non-surgical methods, are eligible to undergo bariatric surgery (National Institute for Health and Care Excellence, 2014). The BMI cut-point criteria can be lowered by 2.5 kg/m^2 for people of Asian ethnicities (National Institute for Health and Care Excellence, 2014).

Currently, the most commonly performed bariatric procedures are sleeve gastrectomy (SG) Roux-en-Y gastric bypass (RYGB) and adjustable gastric banding (AGB) (Buchwald and Oien, 2013; Angrisani et al., 2015). Gastric bypass involves creation of a small gastric pouch from which nutrients flow directly into the mid jejunum, bypassing the majority of the stomach, the duodenum and proximal jejunum. In sleeve gastrectomy, 80-90% of the stomach volume is removed creating a sleeve-like stomach and leaving the remaining gastrointestinal tract intact and allowing a normal nutrient flow (Li et al., 2013; Abu-Jaish and Rosenthal, 2010). The adjustable gastric band procedure involves placing inflatable silicone band around the upper part of stomach in order to create a smaller stomach pouch restricting the amount of nutrients ingested, however gastric band has been found to result in lower weight loss compared with gastric bypass and sleeve gastrectomy and is decreasing in popularity (Picot et al., 2009; Colquitt et al., 2014; Buchwald and Oien, 2013; Angrisani et al., 2015). See figure 2 for an illustration of bariatric procedures.

Gastric bypass and sleeve gastrectomy procedures manipulate the gastrointestinal tract which affects the flow of the nutrients, restricts the volume of food that can be ingested and reduces nutrient absorption. Importantly, bariatric surgery engenders favourable changes in gut-derived signals (Makaronidis and Batterham, 2016) that regulate energy and glucose homeostasis, gut hormones and appetite (Karamanakos et al., 2008; le Roux et al., 2006; Chandarana and Batterham, 2012; Makaronidis and Batterham, 2016). The weight loss that follows bariatric surgery is mainly triggered by reduced energy intake which is a result of reduced appetite, changes in taste and preferences for certain foods, combined with reduced the reward-value of high-energy or energy dense foods (Makaronidis and Batterham, 2016).

Figure 2 Illustration of adjustable gastric band, Roux-en-Y gastric bypass and sleeve gastrectomy procedures [1]



1.3.2 Weight loss from bariatric surgery

Bariatric surgery is currently considered the most effective treatment for short and long-term weight loss in people with severe obesity resulting in between an average weight loss of 26 kg (95% confidence interval [95% CI]: −31, −21) and 38.5 kg (95% CI: −40.4 kg, −36.6 kg) (Gloy et al., 2013; Buchwald et al., 2009; Sjöström et al., 2004; Maggard, 2005; Picot et al., 2009; Colquitt et al., 2014). However, currently there is no consensus on the optimal way to report weight loss from surgery (Dixon, McPhail and O'Brien, 2005). Percentage excess weight loss (%EWL) is the preferred metric used by surgeons, however its use for research purposes has been highly debated (Dixon, McPhail and O'Brien, 2005; Karmali, Birch and Sharma, 2009; van de Laar, de Caluwé and Dillemans, 2011; van de Laar, 2012; Hatoum and Kaplan, 2013; Dallal et al., 2009). %EWL is obtained by dividing weight loss from surgery by excess weight calculated against certain ideal weight or BMI threshold [pre-operative weight – weight at follow-up / (pre-operative weight – ideal weight) x 100]. The main advantage of %EWL is that it quantifies weight loss in relation to a set goal, such as ideal body weight or certain BMI (for example BMI of 25 kg/m^2) and thus can be useful for individual weight loss guidance.

[1] Illustration of bariatric surgery procedures adapted from an illustration by Waler Pories, MD, FACS and accessed from: http://www.hormone.org/questions-and-answers/2012/bariatric-surgery

However, the ideal body weight has not been standardised. The differences in the ideal body weight together with differences in weight at various pre-operative time points (e.g. first visit or surgery date) can cause significant (17%) variation in %EWL (Montero et al., 2011).

Percentage weight loss (%WL) is currently considered the optimal weight loss parameter, as it does not rely on an arbitrary ideal/target and takes into account baseline difference in weight (van de Laar, de Caluwé and Dillemans, 2011; van de Laar, 2012; Hatoum and Kaplan, 2013). Absolute weight loss, in BMI units or kilos lost, is a useful measure both for clinical and research purposes, as it is suitable for setting individual patient goals and easy to compare across studies (Dixon, McPhail and O'Brien, 2005). Studying change in BMI or weight post-surgery has been recommended alongside a relative measure of %WL (van de Laar, de Caluwé and Dillemans, 2011). Absolute weight loss measures are mainly criticised for not taking into account baseline (pre-operation) levels of in body weight or BMI. This criticism can be easily dismissed as pre-surgery or day of surgery weight is routinely recorded and available, thus baseline differences in BMI and weight can be controlled for using appropriate statistical methods (Dixon, McPhail and O'Brien, 2005).

Very few studies applying longitudinal modelling of weight loss from bariatric surgery have been published (Dallal et al., 2009; Baldridge et al., 2015; Douglas et al., 2015; Benoit et al., 2014). Findings from these longitudinal studies show that rapid weight loss in their first few months post-surgery (-1.78 kg/m^2 per month, 95% CI -1.82 kg/m^2, -1.75 kg/m^2 in the first four months; Douglas et al., 2015) slows down usually around 5-12 months post-operation (Song et al., 2008; Douglas et al., 2015; Manning et al., 2015). A nonlinear function has been found to describe weight loss in the first year and beyond (Song et al., 2008; Dallal et al., 2009; Douglas et al., 2015). In the longer term patients' weight loss tends to stabilise and patients may also regain weight (Dallal et al., 2009; Douglas et al., 2015). Identifying poor weight loss during the early post-operative period is important as it has been shown to be strongly associated with smaller maximal weight loss at 1 and 2 years post-op (Manning et al., 2015; Obeidat and Shanti, 2016).

Despite the overall effectiveness of bariatric procedures, not all patients acquire the same benefits from surgery and there is a significant variability in weight loss achieved from surgery. Around 20% of patients do not lose enough weight from the surgery to outweigh its associated costs and risk, and require a revisional surgery (Kellogg, 2011; Khaitan et al., 2005; Maggard, 2005; Snyder et al., 2009). A recent study of 1,456 UK patients has found that

maximal %WL from gastric sleeve varied between 1.1%-58.3% and maximal %WL from gastric bypass varied between 4.1%-60.9% (Manning et al., 2015). A large US study of 73,989 gastric sleeve, bypass and band patients has found that 44.8% of variability in absolute weight loss at 12 months was explained by the bariatric procedure used, followed by baseline weight explaining 18.5% variability and leaving 34.2% of variability unexplained (Benoit et al., 2014). It is plausible that supportive relationships could help explain some of this variability (Elfhag and Rössner, 2005). Section 2.2 describes the current evidence on this association and summarises pathways explaining how social support could promote post-surgery weight loss.

Summary

Sections 1.2 and 1.3 described body weight outcomes studied in this thesis: weight gain over middle and old age as well as weight loss from bariatric surgery. There is good evidence to suggest that for the majority of people body weight increases steadily over middle age until around age 65, after which it declines. Despite increasing evidence on body weight levels and their health consequences in old age, only few longitudinal studies examined BMI trajectories from midlife to old age. Person-level trajectories of WHR, a more precise indicator of metabolically active fat tissue particularly in ageing populations, have not been studied previously.

Bariatric surgery is currently the most effective treatment for severe obesity. Procedures such as gastric bypass and gastric sleeve, manipulate the gastrointestinal tract, trigger changes in appetite, taste and reward values of food, and produce significant weight loss, on average between 26 kg and 38.5 kg. The weight loss is most rapid in the first few months post-surgery and usually slows down from around the 5th month post-operation. Despite the overall effectiveness of gastric bypass or sleeve gastrectomy, not all patients acquire the same benefits from surgery and there is a significant variability in weight loss achieved from surgery.

Supportive relationships could contribute to both weight gain over time and weight loss from surgery. Chapter 2 describes previous evidence on the association between functional and structural social support and body weight in the general and clinical populations. It further discusses explanatory mechanisms and pathways.

Chapter 2 The association between functional and structural social support and body weight

2.1 Social support and body weight in the general population

This chapter is divided into two main parts. The first part reviews the current evidence on the associations between functional as well as structural social support (i.e. relationship status) and body weight. The second part summarises the evidence on various aspects of social support in bariatric surgery patients and their association with weight loss from the surgery. Both parts describe theoretical models and explanatory pathways as well as potential confounders.

2.1.1 Current evidence on the association between functional social support and body weight

The association between social relationships and body weight has been increasingly recognised and studied in the last decade (Christakis and Fowler, 2007; Moore et al., 2009; Hammond, 2010; Moore, 2010; Kouvonen et al., 2011; Croezen et al., 2012; Leroux, Moore and Dubé, 2013; Oliveira et al., 2013; Kershaw et al., 2014; Pachucki and Goodman, 2015; Powell et al., 2015). Previous studies have analysed the association between positive and negative aspects of functional social support and obesity or weight gain in adult populations both cross-sectionally and longitudinally (Wing et al., 1991; Räikkönen, Matthews and Kuller, 1999; Ali and Lindström, 2006; Block et al., 2009; Kouvonen et al., 2011; Croezen et al., 2012; Oliveira et al., 2013; Kershaw et al., 2014). All previous 8 key studies reviewed here measured functional social support with different instruments, with some studies only examining the negative aspects of relationships (Block et al., 2009; Kouvonen et al., 2011), some measuring social support with a single question on support availability (Ali and Lindström, 2006; Oliveira et al., 2013), while others using comprehensive scales measuring various aspects of perceived availability of social support, including: practical support, appraisal support, self-esteem support and belonging support (Räikkönen, Matthews and Kuller, 1999) or a scale rating various positive and negative social experiences involving other people (Croezen et al., 2012). One study did not specify the instrument used (Wing et al., 1991) and the association between social support and body weight was a primary focus of only three previous studies (Kouvonen et al., 2011; Oliveira et al., 2013; Kershaw et al., 2014).

Cross-sectional evidence shows that social support is negatively associated with WHR and that both a lack of the positive aspects of social support and high levels of negative aspects of social support are associated with higher odds of overweight and obesity (Wing et al., 1991; Ali and Lindström, 2006; Croezen et al., 2012). Wing et al. (1991) analysed data on 487 women aged on average 50.1 (±1.6 SD) years from the US Healthy Women Study and found that waist-to-hip ratio (WHR) was negatively associated with social support before and after adjusting for BMI. The social support instrument was not specified. Ali and Lindström (2006) analysed data on 1,967 women aged 18-34 using the Public Health Survey in Scania, Sweden and reported that low emotional support was associated with higher odds of overweight (OR 1.63; 95% CI: 1.24-2.14) and of obesity (OR 1.66; 95% CI: 1.12-2.47). Low instrumental support was also associated with higher odds of overweight, (OR 1.71; 95% CI: 1.26-2.33) and of obesity (OR 2.07; 95% CI: 1.35-3.17). Emotional social support in this study was described as "[reflecting] the opportunity for care, trust and confidence, and emotional contact", while instrumental support aimed to capture "[…] the individual's access to guidance, advice, information, practical services, and material resources from other persons" though the item wording was not included in the paper (Ali and Lindström, 2006). Croezen et al. (2012) analysed data on 4,724 Dutch men and women aged 26-65 years from the Doetinchem Cohort Study and found that being in the highest tertile of negative experiences of social support was positively associated with odds of prevalent overweight (OR 1.23; 95% CI: 1.09-1.40, adjusted for gender, age, educational level, marital status, employment status and study round). Positive experiences of social support were not associated with odds of prevalent overweight and neither positive nor negative experiences of social support were associated with odds of incident overweight (Croezen et al., 2012). In their study, social support was measured using the Social Experiences Checklist which assesses regularity of 8 positive and 8 negative social experiences occurring in contact with other people in the previous month (such as "warmth and friendliness", "esteem", "useful information and suggestions", "[…] pleasant time", "incomprehension", "excessive concern", "[…] someone belittled you", "[…] someone avoided you") validated using data on 36,588 Dutch adults (van Oostrom et al., 1995).

Longitudinal studies found that changes in social support were associated negatively with WC and that both low emotional support and high negative aspects of social support were associated with risk of obesity in men and higher odds of 10% increase in BMI and WC in both men and women (Räikkönen, Matthews and Kuller, 1999; Oliveira et al., 2013; Kouvonen et al., 2011; Kershaw et al., 2014). Räikkönen et al. (1999) studied 120-345 women (depending

on the research question) aged 42-50 at baseline from the US Healthy Women Study and found that changes in social support were negatively associated with changes in WC over time between-individuals, yet not within-individuals. The association ceased to be significant after adjusting for education, physical inactivity and weight (Räikkönen, Matthews and Kuller, 1999). Social support in their study was measured using the Interpersonal Support Evaluation List evaluating social support buffering of stressful events and categorising the perceived availability of support into four 10-item subscales: practical, appraisal, belonging and self-esteem support. Oliveira et al. (2013) analysed data on 3,586 adults aged 18-75 years from longitudinal Swedish Level of Living Survey and found that poor emotional support in 1991 was associated with the risk of obesity in men 9 years later (RR 1.98; 95% CI: 1.1-4.6, after adjusting for confounders such as age, social class, physical activity, alcohol consumption and smoking), but not among women (Oliveira et al., 2013). Social support was measured with a single item "Sometimes we need other people's help and support. Do you have a family member or friend who helps out if you need to talk to someone about personal problems?" and the answers were dichotomised as "yes" and "no" (Oliveira et al., 2013).

Two similar studies using UK and US populations have looked at the longitudinal associations between tertiles of social support, negative aspects of close relationship, BMI and WC. Kouvonen et al. (2011) using data on 3,703 civil servants from the Whitehall II study aged 35-55 years at baseline have shown that exposure to negative aspects of support at the first two study waves was associated with 10% increase in BMI and WC between study waves 3 and 5, also after adjusting for covariates such as baseline BMI, employment grade, smoking status, moderate and vigorous physical activity, daily fruit and vegetable consumption, and common mental disorder (Kouvonen et al., 2011). In the imputed sample, participants reporting negative aspects of support were more likely to move from the overweight category at phase 3 to the obese category at phase 5 compared with participants who did not report negative aspects of support. Negative aspects of support were not associated with a transition from normal BMI to overweight or obesity or with weight reduction among participants with BMI over 25 and 30. Negative aspects of support were measured with a 4-item subscale asking about interactions with the person nominated as the closest in the last 12 months such as "did this person give you worries, problems and stress?", "did talking to this person make things worse".

Kershaw et al. (2014) analysed data from 3,074 CARDIA study participants aged 33-45 years and found that reporting persistently high supportive relationships was associated with

lower odds of ≥10% increase in BMI and WC compared to reporting persistently low supportive relationships (OR 0.58; 95% CI: 0.38-0.86 and OR 0.68; 95% CI: 0.48-0.97 respectively, adjusting for a wide range of demographic, socioeconomic, health behaviour and psychological covariates). Supportive relationships were not statistically associated with absolute changes in BMI and WC in linear regression models. Compared to persistently low negative interactions, persistently high negative social relationships were associated with ≥10% increase in BMI (OR 1.50; 95% CI: 1.00-2.24, fully adjusted) and ≥10% increase in WC (OR 1.62; 95% CI: 1.15-2.29, fully adjusted) as well as mean increase in WC. Increasingly negative interactions were associated with ≥10% increase in WC (OR 1.42; 95% CI: 0.99-2.03, fully adjusted), but not in BMI. Social support in this study was measured with an 8-item scale assessing supportive interactions with four questions measuring emotional and confiding dimensions of social support (i.e. being able to "open up" to friends and family about "a serious problem" and believing that friends and family "really care [about the participant]", "can be relied on to talk about worries" and "understand how [the participant] feels about things"). Unsupportive interactions were measured with four questions commonly used to assess negative aspects of support, namely friends and family "making too many demands", "criticising", "letting them down", "getting on their nerves", rated on a scale 1 "not at all" to 4 "a lot" (Kershaw et al., 2014).

Not all studies found an association between social support and body weight. Block et al. (2009) analysed data on 1,355 adults aged 25-74 years from the MIDUS study and assessed "strain" in close relationships (family, friend, spouse) with four questions commonly used to assess negative aspects of support and additional two questions assessing the relationships with the spouse ("arguing" and "making [the participant] feel tense"). They found no associations between strain in relationships with family, friends and spouses and BMI, except for an association between strain in the relationship with family predicting weight gain among women with higher baseline BMI.

2.1.2 Current evidence on the association between structural social support and body weight

As mentioned in Chapter 1, marital or partnership unions are an important and distinctive source of social support and spouses or partners are often nominated as the main providers of support in mid to late adulthood (Walen and Lachman, 2000). The vast majority of previous studies on structural social support to date have defined it as marital status, rarely

distinguishing between other types of romantic relationship or structural social support aspects. Only one previous study examined the association between structural social support measured with Social Network Index by Berkman and Syme (1979) (which consists of marital status, participation in religious services and membership in clubs and organisations) and WHR (Kaye et al., 1993). Kaye et al. (1993) analysed data on 5,115 adults aged 18-30 from CARDIA study and found that structural social support was associated with lower WHR only among Black African men (Kaye et al., 1993). This association was not significant among Black African women or White men and women.

Many cross-sectional and longitudinal studies consistently show that marriage is associated with higher body weight (Janghorbani et al., 2008; Teachman, 2016; Mata, Frank and Hertwig, 2015; Sobal, Rauschenbach and Frongillo, 1992, 2003; Heineck, 2006; MacInnis et al., 2014; Botoseneanu and Liang, 2011; Sobal and Hanson, 2011; Ortega et al., 2011; The and Gordon-Larsen, 2009; Umberson, Liu and Powers, 2009; Wilson, 2012; Schneider and Grimps, 2013). A study of nationally representative sample of Americans shows that those who married between 1986-1989 gained 1.13 kg/m^2 by 2001 compared to those who remained unmarried (Umberson, Liu and Powers, 2009). Another study of 4,714 community-dwelling US adults aged ≥65 years old reported that those who experienced 5% weight gain in a 3-year period were more likely to be married compared to non-married (Newman et al., 2001). A study of 4,555 adults from 9 European countries also showed that when all countries where combined married individuals had higher BMI than never married counterparts (Mata, Frank and Hertwig, 2015).

Few longitudinal studies have examined the association between marital or romantic relationship status and person-level BMI trajectories (intercept and slope) and their results have been inconclusive (Kahng, Dunkle and Jackson, 2004; Umberson, Liu and Powers, 2009; Ostbye, Malhotra and Landerman, 2011; Murayama et al., 2016; Teachman, 2016). A study of a young population of 12,686 adults from the National Longitudinal Survey of Youth 1979 Cohort, aged 14-21 at baseline, showed that over time (1981-2004) married participants were heavier than single (-0.56 kg/m^2) and divorced (-0.53 kg/m^2) participants (Teachman, 2016). Trajectories of BMI in married participants were increasing at a steeper rate than in single and divorced and these associations were not modified by gender (Teachman, 2016). Similarly, a study of 10,314 middle-aged adults from the Health and Retirement study showed that being married compared to non-married (single and divorced) was associated with higher BMI over time, however the study did not report the effect of marital status on

baseline BMI level and rate of increase (Botoseneanu and Liang, 2011). Two other studies have found that BMI trajectories did not vary by marital status (Kahng, Dunkle and Jackson, 2004; Umberson, Liu and Powers, 2009) with an exception of a steeper decline in BMI in widowed compared with married (Umberson, Liu and Powers, 2009).

There has also been evidence suggesting that marriage can be protective against weight gain (Ostbye, Malhotra and Landerman, 2011; Murayama et al., 2016). A study of 4,869 old Japanese (69.8±7.2 years old) adults, the only non-US based study, found that over 19 years married participants had a less steep linear BMI slope (-0.029, p=0.008 after controlling for household income and size). In their study married participants had higher baseline BMI than non-married by 0.22 kg/m^2, p=0.042, however education seemed to explain this difference (Murayama et al., 2016). Ostbye et al. (2011) using the National Longitudinal Survey of Youth 1979 Cohort data on 9,681 US adults aged 18-49 identified four BMI latent trajectory groups: overweight (increasing within range of overweight), normal weight, late adulthood obesity (crossing obesity at 30 years and remaining until 49) and early adulthood obesity (entering obesity at approx. 19 years and remaining until 49). They further found that years spent being married were associated with less steep trajectories in all four groups**.** Reverse causation between higher BMI trajectories and shorter duration of marriages could not be ruled out (Ostbye, Malhotra and Landerman, 2011).

2.1.3 Theoretical models and pathways linking functional and structural support to body weight

There is currently a lack of a clear conceptual framework explaining the aetiological role of functional social support in excessive adiposity. The main proposed pathways follow the stress buffering and main effect hypotheses and suggest that psychosocial stress resulting from a lack of positive support and social control influences coping and health behaviours. Thus, the majority of key studies on functional social support and higher body weight reviewed in the previous section conceptualise negative or unsupportive relationships as one of the psychosocial stressors contributing to excessive adiposity, particularly central obesity (Wing et al., 1991; Räikkönen, Matthews and Kuller, 1999; Ali and Lindström, 2006; Block et al., 2009; Kershaw et al., 2014). These studies cite research on psychosocial stress and abdominal adiposity in nonhuman primates and the research of Björntorp (See for instance Björntorp 2001); however they do not explicitly discuss how low social support or unsupportive relationships in particular compared to other psychosocial stressors are linked

with: WHR (Wing et al., 1991; Kaye et al., 1993), WC (Räikkönen, Matthews and Kuller, 1999), BMI categories such as underweight (Ali and Lindström, 2006) or weight gain (Block et al., 2009). Only four out of eight studies elaborate on the "stress" pathway by hypothesising that strained, poor quality relationships could lead to excessive neuroendocrine and cardiovascular arousal as well as negative psychological wellbeing and emotions (Croezen et al., 2012; Oliveira et al., 2013; Kouvonen et al., 2011; Kershaw et al., 2014). These psychological and physical states are then believed to encourage unbeneficial coping mechanisms and unhealthy behaviours such as emotional comfort eating or physical inactivity.

The second proposed pathway is social control for healthy coping and behaviours that supportive close relationships are hypothesised to exert. Supportive relationships are conceptualised in the majority of the studies to influence body weight through promoting healthy behaviours such as diet, physical activity, smoking and alcohol consumption (Croezen et al., 2012; Oliveira et al., 2013; Kershaw et al., 2014). There is indeed a vast amount of evidence showing that functional social support is associated with health behaviours such as smoking, fruit and vegetable consumption and vigorous physical activity (Allgöwer, Wardle and Steptoe, 2001; Poortinga, 2006; Croezen et al., 2012; Harvey and Alexander, 2012; Tamers et al., 2013). Low social support has been also associated with irregular sleep hours and sedentary behaviours (Allgöwer, Wardle and Steptoe, 2001; DiMatteo, 2004). Social support measured by the Close Person Questionnaire was linked to maintaining and improving physical activity levels in the Whitehall II study (Kouvonen et al., 2012). A study on 4,724 Dutch adults has reported that low positive aspects of social support were associated low fruit and vegetable consumption, while high negative aspects were associated with smoking, physical inactivity and future non-beneficial changes in alcohol consumption and physical activity (Croezen et al., 2012). Furthermore, married individuals particularly married men experience more social control for healthy behaviours such as healthier diets, less smoking and alcohol drinking from their spouses (Umberson, 1992; Mata, Frank and Hertwig, 2015). Stable marriage has been associated with a decrease in cigarette smoking (both men and women) as well as an increase in number of hours slept per night and physical activity in women (Umberson, 1992). Divorce has been associated with increased smoking in men as well as higher alcohol consumption and less sleep in women (Umberson, 1992).

2.1.4 Moderating and confounding variables in the association between functional and structural social support, and body weight

A modifying effect of gender on the association between functional and structural social support, and body weight has to be considered; however there was a lot of variation in how gender difference was addressed in the previous studies. Three out of eight key studies which examined functional support included only women (Wing et al., 1991; Räikkönen, Matthews and Kuller, 1999; Ali and Lindström, 2006); one stratified their analyses by gender, yet did not explicitly state a formally tested gender interaction (Block et al., 2009); two reported an intention to study modifying effect of gender, however did not report results from the formal test of a gender interaction (Kouvonen et al., 2011; Oliveira et al., 2013); and the remaining two studies reported non-significant tests of gender interaction (Croezen et al., 2012; Kershaw et al., 2014). Out of two studies which reported gender difference in the association between social support and body weight, one found the association in men (Oliveira et al., 2013) and one in women (Block et al., 2009). It is important to acknowledge that none of these studies tested a gender interaction formally, while two studies which have reported formal tests of modifying effect of gender, found no evidence to support a gender difference (Croezen et al., 2012; Kershaw et al., 2014).

One study of structural social support measured with the Social Network Index found that social support was associated with lower WHR only among Black African men (Kaye et al., 1993), however Kaye et al. stratified their analyses by gender without explicitly stating a formally tested gender interaction. In cross-sectional and longitudinal studies assessing structural social support with marital status, marriage has been linked with higher body weight than non-marriage, with some studies suggesting that the association is particularly significant in men (Wilson, 2012), while others reporting no gender difference (Schneider and Grimps, 2013). However, assessing a modifying effect of gender on marriage and body weight is difficult as, similarly to studies of functional support, some studies do not formally test gender interaction (Sobal, Rauschenbach and Frongillo, 2003; Janghorbani et al., 2008) or do not explicitly report a formal gender interaction test (Ostbye, Malhotra and Landerman, 2011; Jeffery and Rick, 2002). Furthermore, four previous studies reported no evidence of gender modification in their findings (Umberson, Liu and Powers, 2009; Schneider and Grimps, 2013; Mata, Frank and Hertwig, 2015; Teachman, 2016).

Various demographic, socioeconomic and behavioural factors should be taken into account in the association between social support and body weight trajectories. Female gender, low socioeconomic status, low education, infrequent physical activity and non-smoking or quitting smoking are associated with higher BMI levels, greater mean BMI changes and steeper BMI increases (Clarke et al., 2009; Hulmán et al., 2014; Jacobsen et al., 2001; He and Baker, 2004; Dugravot et al., 2010; Botoseneanu and Liang, 2012). The effects of ethnicity are less clear and seem to be modified by gender and confounded by socioeconomic factors (Baltrus et al., 2005; Chor et al., 2004). Common mental disorders (anxiety and depression) have been found to be associated with weight gain and obesity in a dose-response manner (Kivimäki et al., 2009). Gender (Schuster, Kessler and Aseltine, 1990), socioeconomic status (Schilling, 1987) and health behaviours such as smoking, fruit and vegetable consumption, vigorous physical activity, regularity of sleep hours, sedentary behaviour (Poortinga, 2006; Harvey and Alexander, 2012; Allgöwer, Wardle and Steptoe, 2001; Tamers et al., 2013; DiMatteo, 2004) and common mental disorders have also been all associated with social support (Schuster, Kessler and Aseltine, 1990; Stansfeld, Fuhrer and Shipley, 1998).

Summary

Previous cross-sectional and prospective studies show that low positive and high negative aspects of functional social support are associated with obesity and weight gain in adult populations (Wing et al., 1991; Räikkönen, Matthews and Kuller, 1999; Ali and Lindström, 2006; Block et al., 2009; Kouvonen et al., 2011; Croezen et al., 2012; Oliveira et al., 2013; Kershaw et al., 2014). Only one study so far has examined person-level trajectories of WC by social support and found no evidence of the association (Räikkönen, Matthews and Kuller, 1999). Person-level trajectories of WHR and BMI by functional social support over midlife and older age remain unexplored.

The majority of previous cross-sectional studies link marriage with higher body weight compared to non-marriage (Sobal, Rauschenbach and Frongillo, 1992; Newman et al., 2001; Schubert et al., 2009; Ortega et al., 2011; Sobal and Hanson, 2011; Dinour et al., 2012; Wilson, 2012; Schneider and Grimps, 2013; Mata, Frank and Hertwig, 2015; Teachman, 2016). However, there are few longitudinal studies of marital status and person-level BMI and they offer inconclusive results, for instance two studies analysing data from National Longitudinal Survey of Youth 1979 Cohort found that married participants were heavier over time and had steeper BMI slopes (Teachman, 2016), while another that marital relationships duration was

associated with less steep BMI trajectories (Ostbye, Malhotra and Landerman, 2011). Studies of older populations also show inconclusive results. A study using data on US older adults found no association between marital status and BMI trajectory (Kahng, Dunkle and Jackson, 2004), while a study on Japanese elders found married participants to have less steep BMI slopes over time (Murayama et al., 2016). Two studies examining middle-aged populations either found no association between marital status and BMI trajectory (Umberson et al., 2009) or did not test BMI trajectories by marital status (Botoseneanu and Liang, 2011).

There is currently a lack of clear conceptual frameworks explaining the aetiological role of social support in excessive adiposity. The main proposed exploratory models and pathways suggest that social support acts as a stress buffer and a main effect and mainly influences healthy coping and behaviours. The role of gender in the association between social support and weight gain remains inconclusive.

Supportive relationships could also influence a very different trajectory – weight loss trajectory in patients undergoing bariatric surgery. The next section describes the current evidence on the association between social support and weight loss from bariatric surgery.

2.2 Social support and weight loss from bariatric surgery

Social relationships of bariatric surgery patients are rarely considered and hardly ever a primary focus of studies that examine post-operative weight loss. A broad literature search (using terms for exposure: social support, supportive, marriage, marital status, romantic relationship, marital satisfaction, relationship satisfaction, relationship quality, family, psychosocial, nonclinical, nonsurgical, social, preoperative + predictors, factors, characteristics and terms for the outcome: bariatric surgery outcome or success, weight loss from bariatric surgery) has identified only eleven studies which report any aspect of social relationships, in all but two of these, marital status of bariatric surgery patients was the only considered factor in their samples (Table 1). Only one study of Danish bariatric surgery patients reported the frequency of meeting with friends and family (29.2% reported meeting with their friends less than weekly and 31.5% reported meeting with their family less than weekly; Nelbom et al., 2010). No study reporting characteristics of social relationships (other than cohabitation vs. living alone: 83.3% vs. 16.7%; Ogden, Hollywood and Pring, 2015) of British patients was identified.

It is thus unsurprising that only twelve previous studies examined functional and structural social support and its association with post-operative weight loss (Table 2). Social support among bariatric surgery literature is often conceptualised as support group attendance (see Table 3 for a review of previous studies). Patients' close, interpersonal relationships and supportive exchanges within them remain unexplored (Wadden et al., 2007; Livhits et al., 2011).

Table 1 Social relationships characteristics of bariatric surgery patients reported in previous studies

Author	N	Age	Procedure	Patients' social relationships characteristics
1. Baldridge et al. (2015) *	162	46.7 ± 10.8	RYGB	42.0% married vs. 58.0% non-married
2. Brandão et al. (2015)	150	min. 21 - max. 64	RYGB + AGB	74.0% married vs. 26.0% non-married
3. Coleman & Brookey (2014)	860	46.9 ± 10.5	RYGB	60.3% married vs. 39.7% non-married
4. Wedin et al. (2014) *	80	47.4 ± 11.2	RYGB + SG + AGB	68.0% married + in a partnership vs. 32% non-married
5. Courcoulas et al. (2015) *	1,513	46 (median)	RYGB	63.2% married + cohabiting vs. 36.8% non-married
6. Hildebrandt (1998)	102	44.5 ± 9.7	RYGB	59.7% married + cohabiting vs. 20.6% single vs. 17.7% divorced + widowed
7. Shiri et al. (2007)	31	40 (mean)	AGB	73.2% married vs. 19.4% single vs. 6.5% divorced
8. Robinson et al. (2014)	274	51.1 ± 8.4	RYGB + SG + AGB	71.0% married + in a partnership vs. 20.0% single vs. 9.0% divorced + widowed
9. Palmisano et al. (2015) *	771	42.3 ± 9.9	RYGB	66.8% married + cohabiting vs. 26.1% single vs. 7.1% divorced + widowed
10. Nelbom et al. (2010) *	89	41 (median)	RYGB	60.7% married vs. 21.3% single vs. 18.0% divorced 78.0% living with family vs. 21.3% living alone 70.8% daily or weekly meeting with friends vs. 29.2% <weekly 68.5% daily or weekly meeting with family vs. 31.5% <weekly
11. Ogden et al. (2015) *	162	45.2 ± 10.84	RYGB	83.3% cohabiting vs. 16.7% living alone

* Prospective study; RYGB (Roux-en-Y gastric bypass), SG (sleeve gastrectomy), ABG (adjustable gastric banding)

2.2.1 Current evidence on the association between functional social support and weight loss from bariatric surgery

A retrospective study of 148 gastric bypass patients found that more patients (96.2%) who achieved successful weight loss (≥50% EWL, n=78) reported receiving support for surgery from friends and family compared with patients (87.1%) who did not achieve successful weight loss (<50% EWL, n=70), p=0.045 (Livhits et al., 2010). Patients who achieved ≥50% EWL compared with those who achieved lower EWL also reported higher emotional support measured with MOS [medical outcomes] Social Support Survey, which asks about received confiding, listening and affection (Livhits et al., 2010). Emotional support was not however associated with higher odds of successful weight loss in regression models adjusting for age, gender and pre-surgery BMI (Livhits et al., 2010). Another retrospective study of 20 gastric bypass patients found that higher emotional support and affection also measured with MOS Social Support Survey were not associated with %EWL, and was associated with higher satisfaction with the surgery outcome and less frequent thoughts of food and eating (Delin, Watts and Bassett, 1995). A prospective study of 131 gastric bypass patients found that interpersonal support measured with two items – "patient has told co-workers of his/her [gastric bypass] plan" and "patient has told friends of his/her [gastric bypass] plan") – was positively associated with BMI change and weight loss at 1 year of follow-up (Lanyon and Maxwell, 2007). Two studies of social support and weight loss from gastric banding reported no significant association. In a retrospective study of 300 gastric band patients, social support (social support scale not defined) was not associated with %EWL, yet was associated with greater satisfaction with bariatric surgery outcome (Vishne et al., 2004). Another prospective study of 44 gastric band patients also found that received social support (defined as social support received from the closest person seen once a week) was not associated with weight loss (Canetti, Berry and Elizur, 2009).

Two studies have also analysed the association between relationship quality and weight loss. One prospective study on gastric bypass patients found that marital dissatisfaction pre-surgery was positively associated with weight loss at 1 year (Hafner, Rogers and Watts, 1990), while another one found no evidence of the association between marital satisfaction and weight loss measured with change in BMI and kilos at 1 year since surgery (Lanyon and Maxwell, 2007). Relationship satisfaction and its association with weight loss is challenging as relationship quality can depend on weight status and change as a result of surgery and weight loss. There is evidence suggesting that pre-operative well-functioning relationships

improve, while less stable relationships might suffer as a results of surgery (Rand, Kuldau and Robbins, 1982; Goble, Rand and Kuldau, 1986; Bocchieri, Meana and Fisher, 2002a; van Hout et al., 2006).

2.2.2 Current evidence on the association between structural social support and weight loss from bariatric surgery

The evidence on the structural aspects of social support and weight loss also remains unclear. In a prospective study of 149 gastric bypass patients, patients with more confidants (>9 confidants compared with <9 confidants) tended to have better weight loss (mean %EWL; 80 ± 24% vs. 59 ± 16%, p=0.13) although statistical significance was not reached (Ray et al., 2003). In a retrospective study of 148 gastric bypass patients, those who achieved ≥50% EWL compared with patients who achieved <50% EWL did not vary in their reports of number of friends (Livhits et al., 2010). The association between marital or relationship status and bariatric surgery outcome also requires more research. Married and single individuals differ in health behaviours which could influence their weight-loss (Umberson, 1992; Mata, Frank and Hertwig, 2015). In well-functioning marriages, spouses might receive support, encouragement and social control for healthy behaviours (Novak and Webster, 2011). A review by van Hout et al. (2005) identified satisfying marriage as one of the factors involved in successful weight-loss; however, others found that single or divorced patients had greater excess weight-loss than married patients when adjusted for demographic and socioeconomic factors (Lutfi et al., 2006; Livhits et al., 2010; Nelbom et al., 2010).

A prospective study of 180 gastric band patients reported that single patients achieved higher %EWL at 1 year post-operation than married (89.8% vs. 77.7%, p=0.04) before and after adjustment for age, gender, ethnicity, parental status, employment status, history of depression, smoking, binge eating, and preoperative BMI (Lutfi et al., 2006). A retrospective study of 148 gastric bypass patients found that being non-married (single or divorced) was associated with higher odds of successful weight loss defined as ≥50% EWL (OR 3.2 95% CI: 1.2-8.5, p=0.03) than being married (Livhits et al., 2010). Three other prospective studies of gastric bypass patients however found that there was no difference between married and unmarried in achieving 50% of EWL (Coleman and Brookey, 2014), mean %EWL at 12 months (Ray et al., 2003) and no association between marital status and weight loss trajectories (Baldridge et al., 2015). One prospective study of mainly gastric bypass patients found that being married pre-operation was associated with 7.17 (95% CI: 1.78-29.93, p=0.006) times

higher odds of successful weight loss defined as ≥50% EWL (Wedin et al., 2014). It is possible that the association between marital or relationship status and weight loss is confounded by the household environment, as a prospective study of 89 gastric bypass patients reported that all patients who failed to achieve successful weight loss (>50% of EWL) reported living with their family, none of them lived alone (Nelbom et al., 2010).

A frequently used conceptualisation of social support amongst bariatric surgery patients is support group attendance. Compared to other forms of social support, evidence on support group attendance is fairly consistent (See Table 3). Nonetheless there are vast differences in the way support groups are run, which limits comparability across the studies. A systematic review and meta-analysis of four previous retrospective studies by Beck et al. (2012) reported that support group attendance was associated with greater weight loss in all studies but one (Hildebrandt, 1998), in which the association did not reach statistical significance. Most of the studies (Song et al., 2008; Orth et al., 2008; Hildebrandt, 1998) found a dose response effect, with more attended appointments associated with higher weight loss (Beck et al., 2012). Another retrospective study not included in the review examined maintaining weight-loss after approximately 3 years from the surgery and found that bariatric surgery support group attendance was associated with higher odds of successful weight loss defined as ≥50% EWL (OR 3.7, 95% CI: 1.3-10.9, p=0.02) adjusted for age, gender and initial BMI (Livhits et al., 2010). Only one published study found no difference in %EWL between support group attendances compared to nonattendance, in gastric sleeve and bypass patients (Monkhouse, Choudry and Woodcock, 2013). Beck et al. (2012) acknowledge a possible publication bias towards studies that report significant, positive results. All studies emphasise the lack of evidence on the association between “organic”, interpersonal relationships of bariatric surgery patients and their association with surgery outcomes.

Table 2 Summary of the evidence on the functional and structural social support and weight loss from bariatric surgery

Author	N	Age	Procedure	Functional social support (inc. relationship quality) and weight loss
1. Livhits et al. (2010)	148	45.9 (mean)	RYGB	▪ Friends' and family's support for surgery and received emotional support [MOS Social Support Survey] higher in ≥50% EWL vs. <50% EWL patients
2. Delin et al. (1995)	20	42.6 ± 9.4	RYGB	▪ Received emotional support [MOS Social Support Survey] not associated with %EWL and positively associated with surgery outcome satisfaction and less frequent thoughts of food and eating
3. Vishne et al. (2004)	300	40.2 ± 10.6	AGB	▪ Social support [scale not defined] not associated with %EWL, yet associated with surgery outcome satisfaction
4. Canetti et al. (2009) *	44	34.2 ± 10.0	AGB	▪ Received social support [social support received from the closest person seen once a week] was not associated with weight loss [measured as change in kilos]
5. Lanyon & Maxwell (2007) *	131	43.1 ± 11.6	RYGB	▪ Social support measured as "patient has told friends/co-workers of his/her [gastric bypass] plan" positively associated with BMI change and weight in kilos change ▪ No association between pre-operative marital satisfaction and change in BMI and kilos at 1 year post-op
6. Hafner et al. (1990) *	71	---	RYGB	▪ Pre-operative marital dissatisfaction positively associated with BMI at 1 year post-op
Author	**N**	**Age**	**Procedure**	**Structural social support and weight loss**
1. Ray et al. (2003) *	149	39.0 ± 10.0	RYGB	▪ >9 vs. ≤9 confidants associated with higher %EWL (80 ± 24% vs. 59 ± 16%, p=0.13) ▪ Married vs. non-married: no difference in mean %EWL
2. Nelbom et al. (2010) *	89	41 (median)	RYGB	▪ Living alone vs. with family: 100% of patients who failed <50% EWL lived with family
3. Lutfi et al. (2006) *	180	43.7 ± 10.4	AGB	▪ Married vs. single: OR 2.6 (95% CI: 1.1-6.5, p=0.04) of failed <53% EWL ▪ Married vs. single: lower mean %EWL (77.7% vs. 89.9%, p=0.04)
4. Livhits et al. (2010)	148	45.9 (mean)	RYGB	▪ Single + divorced vs. married: OR 3.2 (95% CI: 1.2-8.5, p=0.03) of successful ≥50% EWL

5.	Coleman & Brookey (2014)	860	46.9 ± 10.5	RYGB	▪ Married vs. non-married: no difference in % EWL
6.	Baldridge et al. (2015) *	162	46.7 ± 10.8	RYGB	▪ Married vs. non-married: no association between marital status and weight loss trajectory groups (p=0.09)
7.	Wedin et al. (2014) *	80	47.4 ± 11.2	RYGB + SG + AGB	▪ Married vs. non-married: OR 7.17 (95% CI: 1.78-29.93, p=0.006) of successful ≥50% EWL

* Prospective study; % EWL (percentage excess weight loss); RYGB (Roux-en-Y gastric bypass), SG (sleeve gastrectomy), ABG (adjustable gastric banding)

Table 3 Summary of evidence on the association between support group attendance and weight loss

Author	Support group attendance (n)	Age	Procedure	Support group attendance and weight loss
Hildebrandt (1998)	Yes (n=69) No (n=33)	44.5 ± 9.7	RYGB	Attendance vs. non-attendance positively associated with weight loss, however statistical significance was not reached, p=0.08
Elakkary et al. (2006)	Yes (n=10) No (n=28)	45.5 ± 15.1 43.1 ± 12.4	AGB	Attendance vs. non-attendance positively associated with mean decrease in BMI 9.7 ± 1.9 vs. 8.1 ± 2.1, p=0.04
Orth et al. (2008)	Yes (n=18) No (n=28)	---	RYGB + AGB	Attendance vs. non-attendance positively associated with percent decrease in BMI (42% vs. 32% p=0.03)
Song et al. (2008)	>5 (n=28) ≤5 (n=50)	42.0 ± 8.7 42.0 ± 9.7	RYGB	Attendance of >5 support group meetings vs. ≤5 support groups meetings associated with higher %EWL at 9 months (53.6% vs. 45.2%, p<0.05) and 12 months (55.5% vs. 47.1%, p<0.05)
Livhits et al. (2010)	---	45.9 (mean)	RYGB	Attendance vs. non-attendance associated with higher odds of successful weight loss ≥50% EWL (OR 3.7, 95% CI: 1.3-10.9, p=0.02)
Monkhouse et al. (2013)	Yes (n=62) No (n=56)	45.9 (RYGB) 52.5 (SG) 50.0 (RYGB) 60.4 (SG)	RYGB + SG	Attendance vs. non-attendance no difference in %EWL (RYGB, 74.8% vs. 75.6% and SG 51.3% vs. 44.3%, p>0.05)

% EWL (percentage excess weight loss); RYGB (Roux-en-Y gastric bypass), SG (sleeve gastrectomy), ABG (adjustable gastric banding)

2.2.3 Pathways linking functional and structural support to weight loss from surgery

Close, supportive relationships could encourage patients to seek medical treatment for obesity and help with adjusting to lifestyle changes required post-surgery (Elfhag and Rössner, 2005; Liebl, Barnason and Brage Hudson, 2016; Ogle et al., 2016). The surgery, a stressful experience itself, begins the process of an often difficult transition, as patients may experience negative side effects of the surgery such as dumping syndrome (rapid gastric emptying leading to abdominal cramps and diarrhoea) as well as face challenges of new food tolerance, old cravings and adherence to new diet regimen (Liebl, Barnason and Brage Hudson, 2016; Moore and Cooper, 2016; Ogle et al., 2016; McMahon et al., 2006).

However, previous studies reviewed in sections 2.2.1 and 2.2.2 do not explain inclusion of social support in the analyses of weight loss from surgery and do not refer to any theoretical frameworks, such as stress buffering and main effect hypotheses. Instead, they tend to rely on previous findings on the association as a justification of their focus on social support. Only one previous study has defined and tested a potential pathway linking functional social support to weight loss from bariatric surgery. Canetti et al. (2009) have examined emotional eating as a potential mediator of the association between social support and weight loss from a gastric band and nonsurgical means, but found no evidence of mediation by emotional eating in the structural equation models (Canetti, Berry and Elizur, 2009). Canetti et al. (2009) also included movitation for control as a potential factor influencing emotional eating and social support. In their model, motivation for control could impact upon social support which in turn could impact upon weight loss through emotional eating. However, they did not find that movitation for control was associatied with emotional eating or social support.

Previous studies examining the association between structural social support and weight loss also rarely discuss the rationale for studying marital relationship. Those who found that single patients have higher weight loss from surgery compared with married suggested that these results could be explained by single patients having more time for exercise (Lutfi et al., 2006; Livhits et al., 2010) and having to return to employment sooner following the surgery (Lutfi et al., 2006), as full time employment has been associated with better weight loss in previous studies. Others who reported higher odds of successful weight loss in married compared with nonmarried suggested that marriage acts as proxy for social support (Wedin et al., 2014).

Lack of theoretical frameworks in previous studies assessing social support and weight loss from bariatric surgery appears to be part of a bigger trend. A review of functional and structural social support and lifestyle interventions for weight loss has concluded that social support was clearly defined in hardly any studies and despite well-known existing theoretical frameworks, most studies did not explain the rationale behind including social support in a life-style change intervention (Verheijden et al., 2005). Furthermore, social support was often combined with other interventions, such as financial incentives, making distinguishing the effects of social support difficult (Verheijden et al., 2005). A review of 30 intervention studies using social support to target obesity by Leroux et al. (2013) further confirms the inconsistencies in social support definition and commonly occurring lack of acknowledgement of its mechanism of action. Despite Verheijden et al. (2005) and Leroux et al. (2013) calls for more precise definitions of social support and greater focus on "[...] social relational constructs [as] a nonessential intervention resource" instead of "[...] as a channel through which to deliver the intervention [...]" (Leroux, Moore and Dubé, 2013, p.8), quantitative studies still rarely pay much attention to perceived functional support. For instance, a recent RCT study aiming to examine how to best support weight loss, defined support as: monthly brief meetings with research staff to assess progress, using the MyFitnessPal app, feedback on the daily self-weighing progress sent by a researcher by email or training on recognising hunger according to blood glucose level (Taylor et al., 2015).

2.2.4 Factors previously associated with weight loss from surgery

Previous studies have identified common factors associated with higher weight loss from surgery. Young age, preoperative BMI and White ethnicity in studies from US have consistently been positively associated with weight loss (Barhouch et al., 2016; Ortega et al., 2012; Scozzari et al., 2012; Livhits et al., 2012; Palmisano et al., 2015; Courcoulas et al., 2015; Bayham et al., 2012; Harvin, DeLegge and Garrow, 2008). The operation forces modification of eating behaviour, which requires certain lifestyle adjustments. Learning new eating patterns and discovering new tolerances of foods is crucial post-surgery, and is a significant source of distress in the first year post-operation. Therefore, nonsurgical, behavioural and psychological factors are involved particularly in long-term results. Expectedly, health behaviours such as increased physical activity, less disturbed eating pattern (less eating at night, snacking and grazing, or eating as a stress relief and mood regulation) as well as adherence to follow-up appointments are strongly associated with weight-loss from surgery

(Hwang et al., 2009; Elfhag and Rössner, 2005; van Hout, Verschure and van Heck, 2005; Livhits et al., 2010; Sheets et al., 2015; Brandão et al., 2015; Tsai and Wadden, 2005).

Moderately and severely obese individuals often face various physical and social problems and are subject to the stigma of obesity, all of which may hinder adaptation to new lifestyle and lead to failed weight loss (Wadden et al., 2007; Puhl and Heuer, 2009). Bariatric surgery candidates consistently report lower quality of life and many suffer from mood disorders, with up to 48% of patients being diagnosed with anxiety disorders (Abilés et al., 2010; Nelbom et al., 2010; See Wadden et al., 2007 for a review). Coping style, perceived control, self-efficacy (an individual's belief in their ability to achieve goals and complete tasks) may be especially important for dealing with the emotional impact of obesity stigma and with a life-changing event such as bariatric surgery. Coping style and self-efficacy have been found to differ between obese and normal weight individuals as well as between those who manage to lose weight and maintain it, and those who fail to do so (Hörchner et al., 2002; Elfhag and Rössner, 2005; van Hout, Verschure and van Heck, 2005). Self-esteem has also been associated with successful weight loss across many studies (Elfhag and Rössner, 2005; van Hout, Verschure and van Heck, 2005; Livhits et al., 2010; van Gemert et al., 1998).

Health behaviours as well as self-esteem and perceived control or self-efficacy could mediate the association between supportive relationships and weight loss from surgery. Received social support and meaningful relationships have often been theorised to foster individuals' sense of purpose and self-worth (Cohen and Wills, 1985; Lakey and Cohen, 2000; Cohen, 2004; Taylor, 2007; Thoits, 2011) and previous empirical studies report an association between giving support to others and self-esteem or self-worth, self-efficacy, perceived control and mastery (Piferi and Lawler, 2006; Warner et al., 2010; Krause, Herzog and Baker, 1992; Krause, 2016; Schwartz and Sendor, 1999). Supportive relationships could enhance individual's self-esteem and mastery which could translate into beliefs of greater control over one's health and engagement in healthier behaviours.

Summary

Currently very little is known about the social relationships of bariatric surgery patients and previous studies have rarely examined the association between patients' social support and weight loss from surgery. Only one prospective study has found that social support (defined as telling friends and co-workers of plans for surgery) was associated with BMI change and

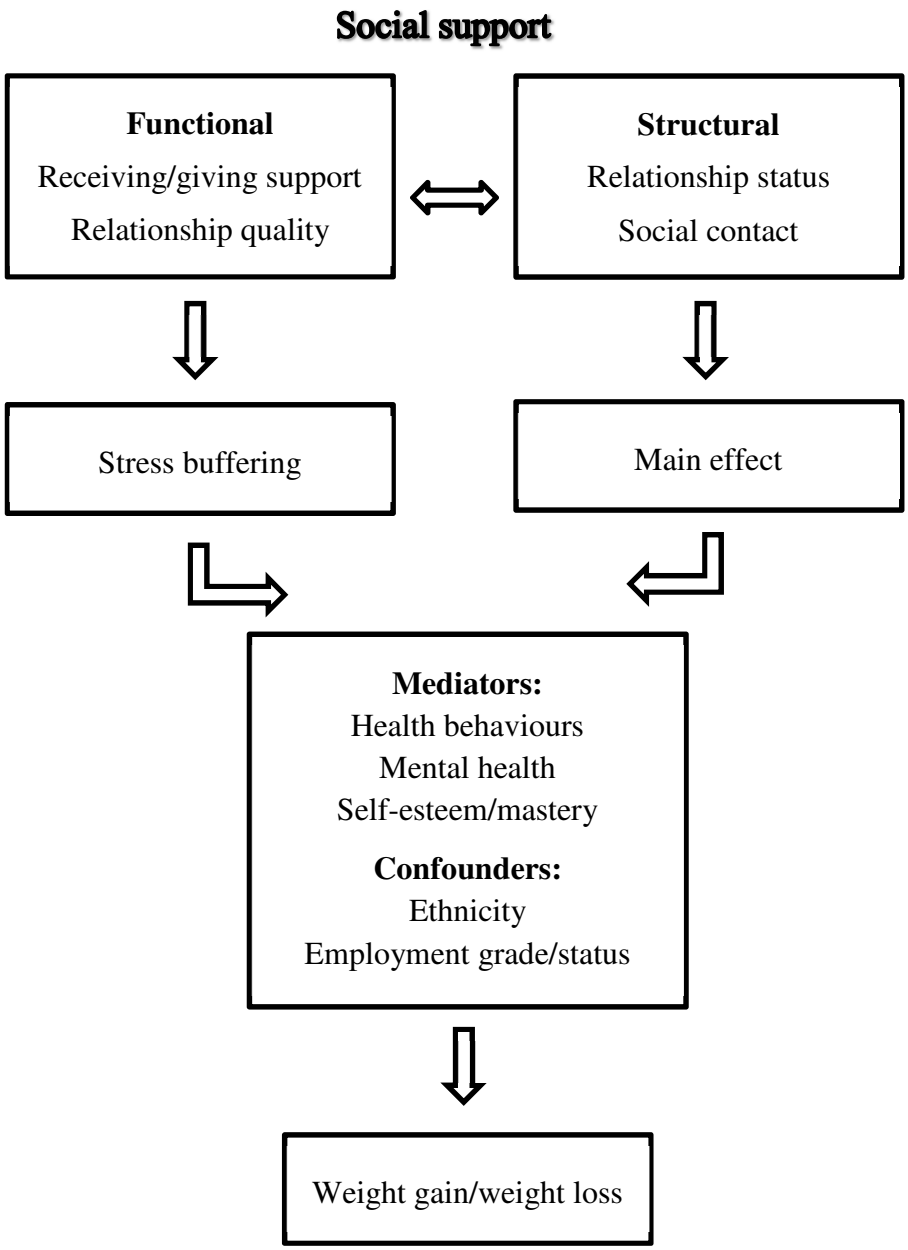
change in kilos in gastric bypass patients, whilst three other retrospective studies found that received social support was not associated with %EWL in patients who underwent a gastric bypass and band. The same retrospective studies also suggested that social support was associated with greater satisfaction with the surgery outcome and less frequent thoughts of food and eating. Similarly, the evidence on marital or relationship status and weight loss remains inconclusive, as seven prospective studies (one including only gastric banding patients) reported: no difference in weight loss among married and non-married patients, higher %EWL in non-married patients and higher odds of successful weight loss (≥50% EWL) in married compared to non-married patients. Although previous reviews identify well-functioning marriage to be positively associated with weight loss, the association between marital satisfaction and weight loss examined in prospective studies remains unclear. Lastly, none of the previous studies refer to any theoretical frameworks such as stress buffering or main effect hypotheses to justify the inclusion of social support as a factor contributing to weight loss from surgery.

Chapter 3 Aims and objectives of this thesis

3.1 The conceptual framework guiding the analyses included in this thesis

Previous studies examining the association between social support and weight gain/weight loss in both general and clinical population have often failed to clearly define social support and refer to theoretical frameworks, such as Stress Buffering and Main Effect, to describe pathways linking social support to their health outcomes. This thesis, based on the long tradition of studies on social support aspects and two main theoretical frameworks, examines two aspects of social support: functional as well as structural aspects of social support. Within functional social support, received and provided social support as well as relationship quality are studied. Within structural support, romantic or marital relationship status and contact with friends and family are investigated. To conceptualise the mechanisms of action of social support on weight outcomes, the studies presented here refer to stress buffering and main effect properties of social support and test whether health behaviours, mental health and self-esteem/mastery mediate the associations between social support types and weight gain/weight loss. Figure 3 shows the conceptual model that guided the analyses of social support and weight gain/weight loss in the general and clinical populations.

Figure 3 Conceptual model used in the analyses of general and clinical populations



3.2 The association between social support and body mass index as well as waist-to-hip ratio in the general population

Previous studies have not captured the multiple aspects of functional social support (emotional, practical, negative) and often failed to conceptualise and discuss potential pathways linking social support to weight gain. In fact, only four out of eight studies discuss how functional social support might influence body weight and health behaviours. Another limitation of the literature on both functional and structural social support and weight gain is the unclear evidence on the modifying effect of gender. Out of eight previous studies on functional social support and body weight, only two reported formal, significance tests of gender modification and three other included only women. Similarly, cross-sectional and longitudinal analyses of structural social support (which in the majority of cases is defined as marital status) and body weight routinely stratify their results by gender, however many of them do not formally test gender interaction or do not explicitly mention a formal gender interaction test, while others report finding no gender interaction in their findings. Categorisation of never-married (single) with divorced, separated, and widowed as "non-married" adds further to confusion over findings, as some previous studies grouped never married, divorced, separated and widowed participants together or excluded divorced and widowed from their analyses.

This study will aim to explore the association between functional/structural social support and BMI/WHR. Functional social support is measured with perceived social support received from the person nominated as the closest in the last 12 months (the Close Persons Questionnaire, CPQ). Part of CPQ, negative aspects of supportive exchanges has been analysed before in the Whitehall II study in relation to odds of BMI and WC increase, however not in its full version. The association between emotional and practical support from the closest person and weight outcomes remains to be explored. It will measure structural social support with relationship status, and it is worth noting the majority of the Whitehall II participants are married. The analysis will conceptualise that both positive and negative aspects of functional social support, as well as structural social support, are mediated by health behaviours: namely diet, physical activity, smoking and alcohol intake. It will further aim to test whether the influence of social support is mediated through common mental disorders such as depression and anxiety. This study will explore a possible moderating effect of gender by running formal tests using a large dataset, namely the Whitehall II study. This leads to the first objective.

3.2.1 Objective 1

Objective 1: Examine cross-sectional associations between BMI/WHR and functional/structural social support in a healthy cohort, test possible moderating effect of gender and assess the contribution of demographic, socioeconomic, behavioural and psychological covariates to these associations

Previous studies on social support and body weight have been mostly cross-sectional. Few longitudinal studies had short follow-up time and examined categories of BMI or set weight gain thresholds such as 10%, thus limiting the available information and statistical power. Only four studies have examined the association between social support and absolute changes in BMI, WC or WHR. However two of them analysed only women and had small sample sizes n<500. Only one study so far has examined within and between person change in functional social support and WC, and found that deviations from an individual's average social support were not associated with fluctuations in weight. This study had a very small sample size n=192 and involved only women. Currently there are no studies of person-level trajectories of WHR and BMI by functional social support over midlife and older age. The gap includes also other aspects of social relationships and has been addressed in a recent review paper by Pachucki and Goodman (2015), who state: "[…] we found no studies of social network and obesity and related behaviors across lifecourse stages. This is a significant gap in the literature and should be an area of focus for future studies." (Pachucki and Goodman, 2015, p.221). The few longitudinal studies of marital status and person-level body weight offer inconsistent results. A previous study reported that married participants had steeper BMI trajectories, while other two studies found the opposite direction with less steep slopes among married participants and two other studies reported no association between marriage and person-level BMI trajectories. Lastly, the vast majority of research on BMI trajectories so far has been carried out using data from US cohorts such as the Health and Retirement Study which use self-reported heights and weights. Self-reported measurements are particularly prone to biases of underestimation of weight and overestimation of height and are a significant limitation of previous research.

This study will explore person-level BMI and WHR trajectories from midlife (ages 30-60) to old age (ages 61-84) using a UK-based cohort of 10,308 healthy civil servant workers and objectively measured height, weight, waist and hip circumference. It will further analyse if these trajectories vary according to levels of social support and relationship status and

investigate the mediating and confounding role of demographic, socioeconomic and health behaviour factors in this association. It will be the first study to analyse the association between social support and BMI/WHR trajectories from midlife to old age as summarised in the next two objectives.

3.2.2 Objectives 2 and 3

Objective 2: Describe person-level body mass index and waist-to-hip ratio trajectories from midlife to old age

Objective 3: Test variations in person-level body mass index and waist-to-hip ratio trajectories according to levels of functional and structural social support

Whilst gradual increases in body weight are the norm in the general population, social support could also be related to trajectories of weight loss. This was examined in patients undergoing bariatric surgery. The following section summarises gaps in current evidence on functional and structural social support and weight loss from bariatric surgery as well as describes study objectives in this clinical population.

3.3 The association between social support and weight loss from bariatric surgery

Pre-operative social support of bariatric surgery patients has been rarely investigated and its association with weight loss, particularly using prospective study design, remains underexplored. Out of five previous studies on functional social support and weight loss, only two use a validated social support scale (MOS Social Support surgery); others define social support as patients telling friends and co-workers of the surgery, social support received from the closest person seen once a week (items and scoring not specified) or do not define the social support scale used. Furthermore, five out of twelve studies on functional and structural social support were retrospective, thus patients were asked about social support and marital or relationship status on average 3 or 4 years post-surgery. As social relationships may change as a result of bariatric surgery, reports using retrospective design are less reliable.

This study will aim to investigate rarely studied pre-surgery functional and structural aspects of social support of bariatric surgery patients, particularly received and provided social support using validated scales of the Close Persons' Questionnaire (Stansfeld and Marmot, 1992) and Providing Social Support Questionnaire (Krause and Markides, 1990). There is a vast amount of evidence linking perceptions of received and available social support to health and increasing evidence on the health-benefits associated with giving social support to others. However, very little is known about the association between functional and structural social support, and weight outcomes – particularly in clinical settings. It is also unclear whether bariatric surgery candidates who do not proceed to surgery or do not comply with post-surgery clinic appointments differ in levels of social support. This leads to the fourth objective.

3.3.1 Objective 4

Objective 4: To measure pre-surgery functional and structural social support of bariatric surgery patients using validated social support scales

Previous studies assessing social support and weight loss from surgery offer inconclusive results. Functional social support has been positively associated with weight loss in a prospective study (Lanyon and Maxwell, 2007), while all previous retrospective studies found no evidence of the association. The evidence on marital or relationship status and weight loss remains inconclusive, as previous studies reported married patients to have both higher, lower and no difference in weight loss when compared with single patients. The majority of these studies suffer from serious methodological shortcomings. Statistical methods used to analyse the association between social support and weight loss were not clearly explained and reported in five of the previous studies.

Only four of the previous studies used mixed models to examine weight loss from bariatric surgery (Dallal et al., 2009; Baldridge et al., 2015; Douglas et al., 2015; Benoit et al., 2014); however they did not assess the association between social support and weight loss. Mixed models allow estimates of the rate of change in weight to vary by social support and make statistically efficient use of repeated weight data. Previous studies also differ widely in follow-up times, with some studies examining weight loss at 1 year post-op, after 1 year post-op and long-term weight loss up to 9.5 years post-op. None of the previous studies focus on weight loss in the first few months, which has been shown to predict weight loss at 1 and 2 years post-surgery (Manning et al., 2015). The early postoperative period might offer a

window of opportunity to address poor weight loss with additional patient support, in order to promote maximal weight loss. Lastly, five out of twelve previous studies on functional and structural social support and weight loss had small sample sizes (n<100, with some being very small, for instance, n=20, Delin, Watts and Bassett, 1995 and n=44, Canetti, Berry and Elizur, 2009).

This study will examine patients' functional and structural social support and their association with weight loss in the first 6 months post-surgery. Supportive interactions and the presence of close social ties could aid patients' adjustments to lifestyle changes during the early months post-surgery, during which patients need to learn the foods they can now tolerate, new eating patterns and physical activity regimens. No previous study has combined relative and absolute measures of weight loss and examined their association with functional and structural social support. This study will investigate the association between pre-surgery social support and %WL at each post-operative follow-up time: 4 weeks, 3 months and 6 months (weight relative to baseline (surgery) weight at each visit), in order to identify whether any association between social relationships and weight depends on the timing of weight loss. As this approach loses statistical power (as it ignores other available weight information and changes occurring within the person-level; Dallal et al., 2009), this study will also model within-person changes in BMI across the 6 months follow-up period. This leads to the fifth and sixth objectives.

3.3.2 Objectives 5 and 6

Objective 5: To describe percentage weight loss in bariatric surgery patients by level of functional and structural social support

Objective 6: To describe person-level BMI trajectory by level of functional and structural social support

Chapter 4 The Whitehall II analyses methodology

This chapter describes study population, exposure and outcome measures, covariates, missing data for cross-sectional and longitudinal analysis, multiple imputation and statistical methods utilised to analyse cross-sectionally whether social support and relationship status at baseline are associated with body mass index (BMI) and waist to hip ratio (WHR) (**Objective 1**) and to analyse longitudinal trajectories of BMI and WHR by baseline level of social support and relationship status (**Objectives 2** and **3**).

4.1 Study population of the Whitehall II Cohort

The Whitehall II study was started in 1985-8 and recruited 10,308 middle-aged (35-55 years old) London-based civil servants working in the offices of 20 Whitehall departments. The study was established to examine the effect of psychosocial and other risk factors on health (Marmot and Brunner, 2005). The study recruited 3,413 women and 6,895 men who held various civil service employment grades – ranging from clerical and office support grades, middle-rank executive grades and senior administrative grades – which varied significantly in salaries (lowest grade range £7,387-£11,917 vs. highest grade range £28,904-£87,620). Participants were invited to complete a questionnaire and attend a research clinic every 5 years for the first 9 phases (phases with an odd numbers) and a questionnaire was sent to them via post in between the clinic appointments (phases with an even number; Table 4). Phase 10 served as a pilot of new mental well-being instruments and at phases 11 and 12 (2015-2017) participants both attended the clinic and completed a questionnaire. The Whitehall II study includes measures on socioeconomic and psychosocial factors including psychosocial factors at work, health behaviours, cardiovascular events and symptoms, mental and general health scales, objectively verified health outcomes and clinical measures of among others anthropometry, neuroendocrine function, metabolism and inflammation markers. The main advantage is a wide spectrum of collected information as well as objectively-measured, repeated clinical examinations and the main limitation of this cohort is that it is not nationally representative. For a full description of the cohort see Marmot and Brunner (2005).

Table 4 Data collection phases of the Whitehall II study

Phase	Dates	Data collected	Number of participants
1	1985-1988	Questionnaire 1 + Clinic	10,308
2	1989-1990	Questionnaire 2	8,132
3	1991-1994	Questionnaire 3 + Clinic	8,815
4	1995-1996	Questionnaire 4	8,628
5	1997-1999	Questionnaire 5 + Clinic	7,870
6	2001	Questionnaire 6	7,355
7	2002-2004	Questionnaire 7 + Clinic	6,967
8	2006	Questionnaire 8	7,173
9	2007-2009	Questionnaire 9 + Clinic	6,761
10*	Feb-Mar 2011	Questionnaire 10 + Clinic	277
11	2012-2013	Questionnaire 11 + Clinic	6,318
12	2015-2017	Questionnaire 12 + Clinic	In progress

* Phase 10 was a pilot of new mental well-being measures introduced at Phase 11

The baseline for the analysis of the study presented in this thesis was considered to be phase 2 (1989-1990), because this was the phase at which measures of social support was included in the questionnaire. Thus the social support measures and covariates used in the analyses and presented below, were taken from phase 2. Anthropometric information of both BMI and WHR was collected at phases: 3, 5, 7, 9 and 11.

4.2 Social support measures

4.2.1 Close Persons Questionnaire

The Close Persons Questionnaire (CPQ) was designed by Stansfeld and Marmot (1992) to measure both social network and social support quality of the participants. CPQ was administered half-way through the 1st phase and was again included at phases: 2, 5, 7, 9 and 11. To derive a new scale of functional social support, questions on emotional, appraisal, practical and informational support, similar to those from Power et al. (1988) and Schaefer et al. (1981), were tested (Stansfeld and Marmot, 1992). Perceived emotional instrumental and negative support in the last 12 months from up to four persons nominated as being

closest to the participant, was reported by participants (at phases 5 onwards only the closest person was nominated). Only social support from the closest person was used in these analyses; Stansfeld and Marmot, 1992). Stansfeld and Marmot (1992) used factor analysis on 15 items in order to refine and operationalise social support information achieving three subscales combined as “confiding/emotional” (Cronbach's α = 0.85, will be referred to as emotional support throughout the text), “practical” (Cronbach's α = 0.82) and “adequacy/worsening aspects of close persons” (Cronbach's α = 0.63, will be referred to as negative aspects (of social support) throughout the text).

Emotional support was measured with 7 items, practical support was assessed with 3 items and negative aspects were assessed with 4 items (Table 5). Each item was rated on a 4-point Likert scale, with higher scores indicating greater emotional and practical support and higher negative aspects. Responses on each item were summed separately for emotional support (min. 0 – max. 21), practical support (min. 0 – max. 9) and negative aspects (min. 0 – max. 12).

Table 5 Close Persons Questionnaire

Question: Thinking about the person you are closest to, please tell us how you would rate the practical and emotional support they have provided for you **IN THE LAST 12 MONTHS**. **How much in the last 12 months...:**

…did this person give you **information, suggestions and guidance that you found helpful**?	Emotional support
…could you **rely** on this person (was this person there when you needed him/her?)	Emotional support
…did this person make you **feel good** about yourself?	Emotional support
...did you **share** interests, hobbies and fun with this person?	Emotional support
...did this person give you **worries, problems and stress**?	Negative aspects
…did you **want** to **confide in** (talk frankly, share feelings with this person)?	Emotional support
…**did you confide in** this person?	Emotional support
...did you trust this person with your most personal worries and problems?	Emotional support
...would you have **liked to** have **confided more** in this person?	Negative aspects
...did talking to this person make things worse?	Negative aspects
...did he/she talk about his/her personal problems with you?	Emotional support
...did you **need** practical help from this person with **major** things? (e.g. look after you when ill, help with finances, children)?	Practical support
…did the person give you **practical help** with **major things**?	Practical support
...would you have **liked more practical** help with major things from this person?	Negative aspects
...did this person give you **practical** help with **small** things when you needed it? (e.g. chores, shopping, watering plants etc.)	Practical support
Answers: (0) not at all (1) a little (2) quite a lot (3) a great deal	

4.2.2 Relationship status

Relationship status was reported by the participants in the questionnaires at all study phases and was grouped in four categories: married or cohabiting, single (never married), divorced or separated, and widowed. For the purpose of analyses presented in this thesis categories of divorced/separated and widowed were combined due to low numbers of widowed participants at phase 2, n=125. For the sake of brevity, participants who reported being married (the vast majority) and those who reported cohabiting are referred to as "married", throughout the text.

4.3 Anthropometric measures

Height was measured using a stadiometer with the head in the Frankfort plane and weight was measured using a portable digital scale (Tanita, Yiewsley, Middlesex, UK). WC was measured in the standing position and unclothed, using a fiberglass tape measure at 600g tension. The smallest circumference was taken at or below the costal margin (Kumari et al., 2010). Hip circumference was measured at the level of the greater trochanter. Waist-to-hip ratio (WHR) was measured by dividing waist circumference measurement (at smallest point) in cm by hip circumference measurement in cm. All of these measurements were taken at clinical phases by a trained nurse. BMI was calculated as weight in kilograms divided by height in meters squared. Both BMI and WHR were measured at phases 3, 5, 6, 7, 9 and 11 and BMI alone at phase 1.

4.4 Covariates

All covariates except ethnicity were obtained from phase 2. Demographic and socioeconomic covariates included: a*ge*, *gender*, *ethnicity* and *civil service employment grade*. Ethnicity was self-reported by the participants at phase 5 and, if missing, ethnicity coded by an observer in the clinic at phase 1 was used. A variable for analyses was derived describing ethnicity in 4 categories: White, South Asian, Black African and Caribbean and Other. Civil service employment categories were based on 12 the civil service grade levels which usually reflect differences in salary, education and job responsibility level. Current or last available civil service employment grades were used and were divided into three grades as used in previous research: administrative (the highest grade), professional (intermediate grade) and clerical/support (the lowest grade).

Health behaviours were self-reported by the participants. Smoking was coded as: current smokers, ex-smokers and never-smokers. Frequency of fruit and vegetable consumption was coded as: once or less per month, one to three times per month, once or twice per week, four times per week, five to six times per week, daily, more than twice a day. Frequency of various mildly, moderately and vigorously energetic sports and physical activities was measured with a Likert Scale (scoring options were: three times a week or more, once or twice a week, about once to three times a month, never/hardly ever). Based on the energy cost involved in a particular activity (relative to laying quietly), a metabolic equivalent score (MET) was calculated according to which activities were assigned to one of the three categories: mild physical activity for MET values lower than 3 hours per week, moderate physical activity for values ranging from 3 to 5.9 METs hours per week and vigorous physical activity MET values of 6 hours per week and greater (Sabia et al., 2012). Alcohol consumption was assessed by self-report of average alcohol (spirits, wine or beer) units consumed per week over in the last seven days. A high weekly alcohol intake was defined as ≥21 units for men and ≥14 units for women (Science and Technology Committee, 2012).

Presence of longstanding illness was assessed with a binary variable [Yes/No] asking about "any longstanding illness, disability or infirmity" and specifying that longstanding means "anything that has troubled [the participant] over a period of time or that is likely to affect [the participant] over a period of time". Participants who answered "Yes" were further asked to specify up to three ailments. Types of illness provided by participants included cancers; blood disorders; heart, blood vessels and circulation complaints; brain and nervous system disorders; complaints of lungs and breathing; problems of the digestive and reproductive systems; mental and psychological complaints; complaints of bones, joints and muscles; problems of the eyes or ears; infectious or parasitic diseases; skin complaints; and other.

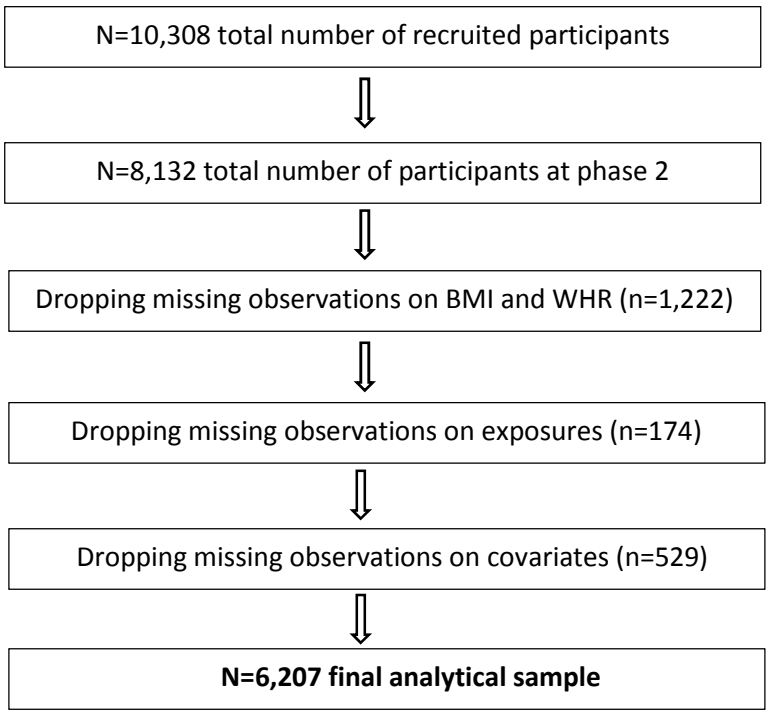
Mental health was assessed using the 30-item version of Goldberg's General Health Questionnaire (GHQ), which is a self-administered questionnaire measuring common mental disorder, by asking about specific complaints and symptoms experienced over the past few weeks. If they occur the response is scored as 1 and 0 if the symptoms/complaints are not present. The scale of the questionnaire is thus between 0 and 30 and cases are considered as those who score 5 and more. This threshold has been found to predict mortality and was previously used in Whitehall II study analyses (Huppert and Whittington, 1995; Kivimäki et al., 2009, 2011). Alternative method of scoring GHQ includes a Likert scale.

4.5 Analytical samples

4.5.1 Missing data and arriving at final analytical sample for cross-sectional analysis

In the first set of analysis the association between social support, relationship status at phase 2 (1989-1990) and BMI and WHR at phase 3 (1991-1994) was examined. The total number of participants at phase 2 was 8,132 (n=8,815 at phase 3 and present at both phases, n=7,571). Observations on BMI and WHR were missing for n=1,222 of participants at phase 3, while observations on the Close Persons Questionnaire and relationship status were missing for n=174 participants. For participants who had information on outcomes and all covariates, but had missing social support information at phase 2 (n=82), social support scores from phase 1 were used. After excluding those with missing values for covariates (n=529), the final analytical sample size was 6,207 with complete data (Figure 4).

Figure 4 Diagram showing the process of arriving at final analytical sample for complete case cross-sectional analysis



Missing exposure and outcome observations were associated with older age, female gender, non-White ethnicities, lower employment grades and less favourable health behaviours (current smoking and lower frequency of mild, moderate and vigorous physical activity),

lower alcohol units consumption as well as higher emotional support score and divorced/widowed marital status, all $p<0.05$.

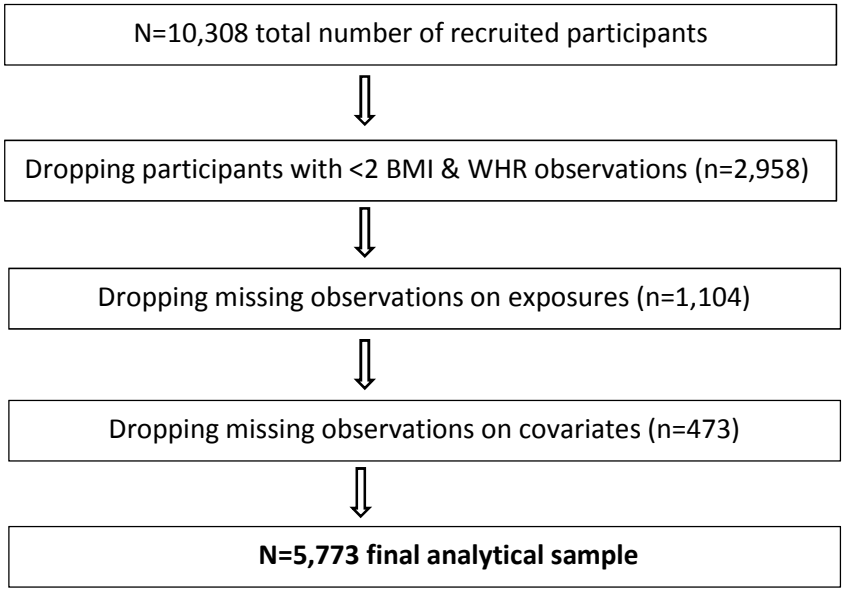
4.5.2 Missing data and arriving at final analytical sample for longitudinal analysis

Longitudinal analysis examines the association between baseline social support and relationship status from phase 2 (1989-1990) and trajectories of BMI and WHR over phases 3 (1991-1994), 5 (1997-1999), 7 (2002-2004), 9 (2007-2009) and phase 11 (2012-2013), adjusting for covariates measured at phase 2. Participants who provided social support data at phase 2 and those who provided at least 2 measures of either BMI (n=7,420, 71.98%) or WHR (n=7,356, 71.36%) were included in the analysis, n=7,350. The majority of participants had 3+ BMI and WHR observations (Table 6). Of these, 6,246 had CPQ data, and of these 5,773 had complete covariate data (Figure 5).

Table 6 Missing observations in BMI and WHR

Missing BMI Observations	Frequency	Percent	**Missing WHR observations**	Frequency	Percent
0 missing	3,775	36.62%	0 missing	3,378	32.77%
1 missing	1,788	17.35%	1 missing	2,066	20.04%
2 missing	959	9.30%	2 missing	1,037	10.06%
3 missing	898	8.71%	3 missing	875	8.49%
4 missing	1,313	12.74%	4 missing	1,358	13.17%
5 missing	1,575	15.28%	5 missing	1,594	15.46%
Total	10,308	100.00%	Total	10,308	100.00%

Figure 5 Diagram showing the process of arriving at final analytical sample for longitudinal analysis



Similarly to missingness patterns in cross-sectional analyses, participants with no or only one BMI or WHR observation were older at baseline (47.5 vs. 49.3 years, $p<0.001$); and were more likely to be women, South Asian and Black African or Black Caribbean, current smokers and in lower civil service employment grades, $p<0.05$. They also reported lower consumption of fruits and vegetables and of alcohol (10. 28 vs. 9.12 units per week, $p<0.01$) and less mild, moderate and vigorous physical activity, as well as higher emotional support. Participants with missing information on emotional support, practical support or negative aspects were older at baseline; and were more likely to be women, South Asian, Black African, Black Caribbean, current smokers or in lower civil services employment grades. They also reported lower consumption of fruits and vegetables and of alcohol units per week and less mild, moderate and vigorous physical activity.

4.5.3 Multiple imputation

One assumption of multiple imputation is that data are missing at random. Inclusion of variables that are related to likelihood of missingness or to variables of substantive interest is recommended (White, Royston and Wood, 2011; Azur et al., 2011). Although outcomes, exposures, covariates and auxiliary variables are included in the imputation part, there are options for selecting subsets of the fully imputed dataset for the analytical part of the modelling – for example limiting the sample to those with complete outcome data. The

imputation model included all outcomes, exposures and covariates as well as auxiliary variables (previous employment grade and self-rated health) that might help to predict missingness more accurately (White, Royston and Wood, 2011; Azur et al., 2011). Analyses were limited to the subsample with complete outcome and exposure data. Missing observations on covariates were imputed using multiple multivariate imputation by chained equations with 10 cycles (missingness in covariates was <10%), generating 10 complete datasets. Multiple imputation generates plausible values for missing data drawing on observed data and including random components to account for variability and uncertainty (White, Royston and Wood, 2011).

The same imputation strategy was used for longitudinal analysis, making the final analytical samples n=6,718 and n=6,238 for cross-sectional and longitudinal analyses respectively.

The main analyses presented in the thesis are based on complete cases. Results based on cross-sectional and longitudinal analyses using the imputed datasets can be found in the Appendices I and IV.

4.6 Statistical methods

Measures of social support were highly skewed and in accord with previous analyses (Fuhrer et al., 1999; Stansfeld, Fuhrer and Shipley, 1998; Fuhrer and Stansfeld, 2002) all support measures were divided into tertiles for analyses. Highest tertiles indicated high emotional and practical support and as well as high negative aspects of support (Fuhrer et al., 1999; Fuhrer and Stansfeld, 2002; Kouvonen et al., 2011). BMI and WHR were used as continuous variables.

4.6.1 Cross-sectional analysis

Bivariate analyses were used to examine the association between relationship status, social support and each covariate used in the study (Tables 8 and 9) as well as BMI and WHR and each covariate (Tables 10 and 11). Pearson's chi-squared test (χ^2) was used to examine associations between categorical variables.

To test objective 1, linear regression analysis was used to model the association between relationship status and social support, first with BMI and then WHR. Each exposure variable (relationship status and three social support types) was examined separately in a series of

models. In the first model gender and age were included. An interaction between gender and social support was also included in the initial model. Model 2 additionally included ethnicity and civil servant employment grade (as well as longstanding illness in models with practical support). Model 3 additionally included the health behaviours: smoking status, alcohol consumption (units/wk.), mild, moderate and vigorous physical activity and fruit and vegetable consumption. Model 4 additionally included General Health Questionnaire caseness.

4.6.2 Longitudinal analysis

To test objectives 2 and 3, growth curve analysis was used to explore trajectories of BMI and WHR over two decades of follow-up from midlife to old age and to examine whether these trajectories vary as a function of social support levels and relationship status. Person-level trajectories of BMI and WHR were estimated using separate multilevel growth models with measurement occasion nested within participant. Time was measured as follow-up time (time elapsed since baseline phase 2) and baseline age was adjusted for. Follow-up time was chosen as the measure of time due to unevenly spaced follow-up waves in the Whitehall II study. The basic growth model (See Figure 8) included fixed term for an intercept (capturing baseline BMI or WHR), a linear term for time (capturing the linear increase in BMI or WHR each year of follow-up) and a quadratic term for time (capturing nonlinear increase in BMI and WHR). Support, support by time and support by time squared interaction terms were added to allow trajectories to vary by social support tertile. Gender and baseline age (centred at 47 years) were additionally included as covariates in the basic growth model (Model 1, See Figure 9). Random estimates were included for the intercept and the linear slope.

Figure 6 Basic growth models of BMI/WHR trajectories

$$y\ (\mathrm{BMI/WHR})_{ij} = \beta_0 + \beta_1 t_{ij} + \beta_2 t_{ij}^2 + u_{0j} + u_{1j}t_{ij} + e_{ij}$$

BMI/WHR observation at occasion **i** for individual **j**

β_0	the overall intercept for all individuals
t_{ij}	time at which measurement i was taken for individual j
$\beta_1 t_{ij}$	linear change in BMI/WHR with time (growth rate)
$\beta_2 t_{ij}^2$	non-linear change in BMI/WHR with time

Random estimates:

e_{ij}	an occasion-specific within-person error
u_{0j}	the difference between an individual's BMI/WHR intercept from the overall β_0
u_{1j}	the difference between an individual's linear BMI/WHR slope from the overall β_1

Figure 7 Basic growth models testing the association between social support and BMI/WHR trajectories adjusted for gender and age at baseline (Model 1)

BMI trajectory = constant + time + time^2 + baseline support + support x time + support x time^2 + gender + baseline age + random estimates

WHR trajectory = constant + time + time^2 + baseline support + support x time + gender + baseline age + random estimates

Interaction between gender and social support was also tested in the basic model comparing the models with Likelihood Ratio test. The associations were adjusted for covariates in an additive manner, first demographic and socioeconomic (as well as longstanding illness in models with practical support) were controlled for (Model 2), then health behaviours were added (Model 3), lastly a fully-adjusted model included all above mentioned covariates and General Health Questionnaire caseness (Model 4). In sensitivity analysis, in order to ensure that the results for relationship status are not biased by changes that occur over more than two decades, especially in the divorced/widowed groups, BMI and WHR trajectories were run in a sample of participants who remain in their relationship status category over the whole follow-up period, n=4,049 (after applying the same complete case criteria).

This study will not use latent body weight trajectories analysis, unlike some other studies (Zheng, Tumin and Qian, 2013; Botoseneanu and Liang, 2013; Kuchibhatla et al., 2013; Zajacova and Ailshire, 2014; Zajacova et al., 2015; Murayama et al., 2015). There is a vast amount of evidence showing modest yet gradual increase in body weight over midlife, followed by weight loss and changes in body composition associated with ageing (Jacobsen et al., 2001; Kahng, Dunkle and Jackson, 2004; McDowell et al., 2008; Hughes et al., 2004; Kuk et al., 2009). Although latent curve analysis is more flexible and allows to test various underlying body weight trajectory subgroups with separate intercepts and slopes (Chou, Bentler and Pentz, 1998), it can produce conflicting results as longitudinal body weight data are sensitive to model assumptions (Zajacova et al., 2015), thus studies using the same datasets have produced different results (Zheng, Tumin and Qian, 2013; Zajacova and Ailshire, 2014; Zajacova et al., 2015; Ostbye, Malhotra and Landerman, 2011; Teachman, 2016).

Chapter 5 Cross-sectional and longitudinal associations between social support and BMI/WHR in general population

The analysis of the Whitehall II study was divided into two main stages. Firstly, the associations between social support measured at phase 2 (1989-1990) and BMI/WHR measured at phase 3 (1991/1994) were analysed using linear regression. Secondly, longitudinal anthropometry data was utilised to examine social support at phase 2 and person-level trajectories of BMI and WHR over later phases of the study (3, 5, 7, 9, 11).

5.1 Cross-sectional analysis results

This section presents findings from descriptive analyses of the study population used in cross-sectional analyses (n=6,207), bivariate association between covariates and both exposures and outcomes, and finally linear regression models of BMI and WHR by social support and relationship status. The results presented in the main tables are based on complete cases. Analyses on the imputed dataset (n=6,718) are presented in the Appendix I and show similar findings.

5.1.1 Descriptive analysis of participants included in the cross-sectional analysis

The participants included in the analyses were predominantly men (70.4%) and on average 47.58 years old (Table 7). Mean BMI was 25.3 kg/m^2 and mean WHR was 0.902 for men and 0.772 for women. Eighty five percent of participants were in administrative or professional employment grades and 92.4% were White. Approximately 35.8% of participants stated that they suffer from longstanding illness, 13.6% were current smokers and 59.9% consumed fruit and vegetables on a daily basis. Infrequent physical activity was reported for 2.2% (mild exercise), 12.8% (moderate exercise) and 61.1% (vigorous exercise) of the participants. Over 14% of participants reported high alcohol consumption (defined as over 14 and 21 alcohol units in a week for women and men respectively). Almost 30% of participants scored 5 or higher on GHQ scale. Table 7 also shows functional and structural aspects of social support. Median emotional support was 15.5 out of 21, median practical support was 5.5 out of 9 and median of negative aspects of support was 2.5 out of 12. Distribution of social support scores was slightly skewed leading to uneven distribution of tertiles. Seventy seven percent of participants were married or cohabiting.

Table 7 Descriptive table of participants' characteristics, complete case analysis n=6,207. All variables were collected at phase 2 (1989-1990) except for BMI and WHR measured at phase 3 (1991-1994).

	N (%)
Gender	
Men	4,370 (70.4)
Women	1,837 (29.6)
Age [mean (95% CI)]	47.58 (47.42-47.73)
BMI [mean (95% CI)]	25.26 (25.16-25.35)
WHR: men [mean (95% CI)]	0.902 (0.900-0.904)
WHR: women [mean (95% CI)]	0.772 (0.769-0.775)
Employment grade	
Administrative	2,297 (37.0)
Professional/Executive	2,980 (48.0)
Clerical/support	930 (15.0)
Ethnicity	
White	5,737 (92.3)
South Asian	278 (4.5)
Black African & Caribbean	151 (2.5)
Other	41 (0.7)
Longstanding illness	
Yes	2,221 (35.8)
No	3,986 (64.2)
Smoking status	
Never-smoker	3,132 (50.5)
Ex-smoker	2,230 (35.9)
Current smoker	845 (13.6)
Freq. of fruit & veg intake	
Less than daily	2,490 (40.1)
Daily and more	3,717 (59.9)
Freq. of mild exercise	
>3/week	4,191 (67.5)
1-2/week	1,535 (24.7)
1-3/month	350 (5.6)
Seldom	131 (2.2)

Freq. of moderate exercise	
>3/week	803 (12.9)
1-2/week	2,567 (41.4)
1-3/month	2,044 (32.9)
Seldom	793 (12.8)
Freq. of vigorous exercise	
>3/week	342 (5.5)
1-2/week	868 (14.0)
1-3/month	1,205 (19.4)
Seldom	3,792 (61.1)
GHQ score	
< 4	4,354 (70.2)
≥ 5	1,853 (29.8)
Alcohol intake*	
Low <14/21 units	5,287 (85.2)
High >14/21 units	920 (14.8)
Functional social support	
Emotional support; mean (SD) / median (min.-max.)	15.09 (4.03) / 15.5 (0-21)
Tertile 1 (low)	2,131 (34.3)
Tertile 2	2,173 (35.0)
Tertile 3 (high)	1,903 (30.7)
Practical support; mean (SD) / median (min.-max.)	5.45 (2.55) / 5.5 (0-9)
Tertile 1 (low)	2,279 (36.7)
Tertile 2	2,179 (35.1)
Tertile 3 (high)	1,749 (28.2)
Negative aspects; mean (SD) / median (min.-max.)	2.79 (2.11) / 2.5 (0-12)
Tertile 1 (low)	2,249 (36.2)
Tertile 2	2,195 (35.4)
Tertile 3 (high)	1,763 (28.4)
Structural social support	
Relationship status	
Married/cohabiting	4,781 (77.0)
Single	905 (14.6)
Divorced	440 (7.1)
Widowed	81 (1.3)

*Recommended maximum alcohol intake per week for men: 21 units and for women: 14 units

5.1.2 Association between social support, relationship status and covariates

When compared to women, men reported less emotional support, more practical support and were more likely to be married. Age was positively associated with emotional support and negatively with practical and negative support. Emotional and practical social support and being married were positively associated with beneficial health behaviours and GHQ score (Tables 8 and 9).

Table 8 Covariates by functional social support, complete case analysis, n=6,207. All variables were collected at phase 2 (1989-1990).

	Emotional support		**Practical support**		**Negative support**	
N / (Column %)	1st tertile	3rd tertile (**ref**)	1st tertile	3rd tertile (**ref**)	1st tertile	3rd tertile (**ref**)
	N=2,131	N=1,903	N=2,279	N=1,749	N=2,249	N=1,763
Men vs. Women	1,555 (73.0)*	1,324 (69.6)	1,436 (63.0)†	1,375 (78.6)	1,564 (69.5)	1,233 (69.9)
Age **[mean (SD)]**	47.43 (5.98)*	47.92 (6.08)	47.87 (6.13)†	46.96 (5.9)	48.30 (6.1)†	47.34 (5.96)
Clerical vs. admin. and exec. grades	306 (14.4)	280 (14.7)	422 (18.5)†	230 (13.2)	835 (37.1)	622 (25.3)
Never-smoker **(ref)**	1,069 (50.2)	942 (49.5)	1,155 (50.7)	890 (50.9)	1,165 (51.8)	872 (49.5)
Ex-smoker	755 (35.4)	721 (37.9)	760 (33.4)*	675 (38.6)	786 (35.0)	623 (35.3)
Current smoker	307 (14.4)	240 (12.6)	364 (16.0)†	184 (10.5)	298 (13.3)	268 (15.2)
<Daily vs. daily fruit & veg intake	952 (44.7)†	648 (34.1)	993 (43.6)†	639 (36.5)	851 (37.8)†	771 (43.7)
3/week vs. less mild exercise	1,377 (64.6)**	1,315 (69.0)	1,467 (64.4)†	1,223 (69.9)	1,552 (69.0)	1,158 (65.7)
1-3/week vs. less moderate exercise	1,089 (51.1)†	1,084 (57.0)	1,152 (50.6)†	1,005 (57.6)	1,233 (54.8)	952 (54.0)
1-3/week vs. less vigorous exercise	406 (19.1)	387 (20.3)	411 (18.0)**	385 (22.0)	414 (18.4)	346 (19.6)
< 14/21 alcohol units vs. > 14/21 units	1,792 (84.1)	1,625 (85.4)	1,898 (83.3)†	1,538 (87.9)	1,936 (86.1)	1,492 (84.6)
GHQ score ≤4 vs. >5	1,419 (66.6)†	1,409 (74.0)	1,590 (69.8)	1,222 (69.9)	1,839 (81.8)†	996 (54.5)

* p<0.05; ** p<0.01; † p<0.001, Recommended maximum alcohol intake per week for men: 21 units and for women: 14 units

Table 9 Covariates by relationship status, complete case analysis, n=6,207. All variables were collected at phase 2 (1989-1990).

	Relationship status		
N / (Column %)	Married/co-habiting (**ref**)	Single	Divorced/widowed
	N=4,781	N=905	N=521
Men vs. Women	3,658 (76.5)	503 (55.6)†	209 (40.1)†
Age **[mean (SD)]**	47.71 (6.02)	46.34 (6.00)†	48.49 (5.99)*
Clerical vs. admin. and exec. grades	608 (12.7)	180 (19.9)†	142 (27.3)†
Never-smoker **(ref)**	2,346 (49.1)	536 (59.2)	250 (48.0)
Ex-smoker	1,835 (38.4)	230 (25.4)†	165 (31.7)
Current smoker	600 (12.6)	139 (15.4)	106 (20.4)†
<daily vs. daily+ fruit & veg intake	1,849 (38.7)	396 (43.8)**	245 (47.0)†
3/week vs. less mild exercise	3,297 (69.0)	562 (62.1)†	332 (63.7)*
1-3/week vs. less. moderate exercise	2,692 (56.3)	432 (47.7)†	246 (47.2)†
1-3/week vs. less vigorous exercise	975 (20.4)	147 (16.2)**	88 (16.9)
<14/21 alcohol units vs. > 14/21 units	4,086 (85.5)	769 (85.0)	432 (82.9)
GHQ score ≤4 vs. >5	3,423 (71.6)	616 (68.1)*	315 (60.5)†

* p<0.05; ** p<0.01; † p<0.001, Recommended maximum alcohol intake per week for men: 21 units and for women: 14 units

5.1.3 Associations between BMI, WHR and covariates

Higher BMI was associated with older age, female gender, Black African and Caribbean ethnicity, clerical employment grade, ex-smoking status, lower frequency of all types of physical activity, higher alcohol intake (Table 10). Higher WHR was associated with older age, South Asian ethnicity, clerical employment grade, ex-smoking and current cigarette smoking, less frequent fruit and vegetable consumption and lower frequency of all types of physical activity and higher alcohol intake in men. In women, higher WHR was additionally associated with Black African and Caribbean ethnicity and lower GHQ score (Table 11).

Table 10 BMI by covariates, complete case analysis, p=6,207. BMI collected at phase 3 (1991-1994) and covariates at phase 2 (1989-1990).

	Body Mass Index		
	N	Mean (95% CI)	*P*
Age			
<40	649	24.6 (24.4-24.9)	*<0.001*
40-44	1,878	25.0 (24.8-25.1)	
45-49	1,411	25.3 (25.1-25.5)	
50-54	1,276	25.6 (25.4-25.8)	
>55	993	25.7 (25.5-26.0)	
Gender			
Men	4,370	25.1 (25.0-25.2)	*<0.001*
Women	1,837	25.6 (25.4-25.8)	
Ethnicity			*<0.001*
White	5,737	25.2 (25.1-25.3)	
South Asian	278	25.2 (24.7-25.6)	
Black African & Caribbean	151	28.0 (27.1-28.8)	
Other	41	25.0 (23.6-26.3)	
Employment grade			
Administrative	2,297	24.9 (24.8-25.2)	*<0.001*
Professional	2,980	25.3 (25.1-25.4)	
Clerical	930	26.1 (25.8-26.4)	
Smoking			
Never-smoker	3,132	25.0 (24.9-25.1)	*<0.001*
Ex-smoker	2,230	25.6 (25.4-25.7)	
Current smoker	845	25.4 (25.1-25.6)	
Fruit & veg consumption			
Non-daily	2,490	25.4 (25.2-25.5)	*0.032*
Daily	3,717	25.2 (25.1-25.3)	
Mild physical activity			
>3 /week	4,191	25.1 (25.0-25.2)	*<0.001*
1-2 /week	1,535	25.4 (25.2-25.6)	
1-3 /months	350	26.3 (25.9-26.7)	
Seldom	131	26.7 (25.8-27.6)	
Moderate physical activity			
>3 /week	803	24.9 (24.6-25.1)	*<0.001*
1-2 /week	2,567	25.2 (25.1-25.4)	
1-3 /months	2,044	25.3 (25.1-25.4)	
Seldom	793	25.7 (25.4-26.0)	
Vigorous physical activity			
>3 /week	342	24.2 (23.9-24.5)	*<0.001*
1-2 /week	868	24.8 (24.6-25.0)	
1-3/months	1,205	25.2 (25.0-25.4)	
Seldom	3,792	25.5 (25.4-25.6)	
Alcohol consumption*			
< 14/21 units	5,287	25.2 (25.1-25.3)	*<0.001*
> 14/21 units	920	25.7 (25.5-25.9)	
GHQ score			
≤ 4 units	4,354	25.3 (25.2-25.4)	*0.799*
≥ 5 units	1,853	25.2 (25.1-25.4)	

*Recommended maximum alcohol intake per week for men: 21 units and for women: 14 units

Table 11 WHR by covariates for men and women, complete case analysis, n=6,207. WHR collected at phase 3 (1991-1994) and covariates at phase 2 (1989-1990).

	Waist to Hip Ratio			
	N	**men:** mean (95% CI)	N	**women:** mean (95% CI)
Age				
<40	467	0.884 (0.879-0.890)	182	0.750 (0.741-0.758)
40-44	1,401	0.892 (0.889-0.895)	477	0.760 (0.754-0.766)
45-49	977	0.905 (0.901-0.908)	434	0.767 (0.760-0.773)
50-54	863	0.913 (0.909-0.917)	413	0.784 (0.777-0.790)
>55	662	0.928 (0.913-0.922)	331	0.795 (0.787-0.802)
p value		*<0.001*		*<0.001*
Ethnicity				
White	4,102	0.900 (0.899-0.902)	1,635	0.768 (0.764-0.771)
South Asian	190	0.934 (0.926-0.943)	88	0.807 (0.795-0.819)
Black African & Caribbean	59	0.910 (0.896-0.925)	92	0.819 (0.802-0.836)
Other	19	0.911 (0.886-0.935)	22	0.775 (0.744-0.805)
p value		*<0.001*		*<0.001*
Employment grade				
Administrative	2,008	0.898 (0.895-0.900)	289	0.758 (0.750-0.765)
Professional	2,100	0.904 (0.901-0.906)	880	0.765 (0.761-0.770)
Clerical	262	0.921 (0.913-0.928)	668	0.788 (0.782-0.793)
p value		*<0.001*		*<0.001*
Smoking				
Never-smoker	2,118	0.894 (0.891-0.896)	1,014	0.766 (0.762-0.770)
Ex-smoker	1,725	0.908 (0.905-0.910)	505	0.776 (0.770-0.782)
Current smoker	527	0.916 (0.910-0.921)	318	0.785 (0.777-0.792)
p value		*<0.001*		*<0.001*
Fruit & veg consumption				
Non-daily	1,859	0.905 (0.902-0.908)	631	0.778 (0.772-0.783)
Daily	2,511	0.900 (0.898-0.902)	1,206	0.769 (0.766-0.773)
p value		*0.006*		*0.014*
Mild physical activity				
>3 /week	3,033	0.898 (0.896-0.901)	1,158	0.771 (0.767-0.775)
1-2 /week	1,011	0.906 (0.902-0.910)	524	0.771 (0.765-0.776)
1-3 /months	257	0.921 (0.914-0.928)	93	0.786 (0.771-0.801)
Seldom	69	0.932 (0.918-0.945)	62	0.799 (0.780-0.818)
p value		*<0.001*		*0.004*
Moderate physical activity				
>3 /week	605	0.885 (0.880-0.889)	198	0.785 (0.776-0.795)
1-2 /week	1,903	0.902 (0.900-0.905)	664	0.766 (0.761-0.771)
1-3 /months	1,454	0.906 (0.903-0.909)	590	0.770 (0.764-0.775)
Seldom	408	0.912 (0.906-0.918)	385	0.780 (0.772-0.787)
p value		*<0.001*		*<0.001*

Vigorous physical activity				
>3 /week	289	0.876 (0.870-0.882)	55	0.751 (0.735-0.767)
1-2 /week	723	0.889 (0.885-0.893)	146	0.762 (0.752-0.772)
1-3 /months	985	0.902 (0.898-0.905)	213	0.766 (0.758-0.775)
Seldom	2,373	0.909 (0.907-0.912)	1,388	0.775 (0.771-0.779)
p value		*<0.001*		*0.007*
Alcohol consumption*				
< 14/21 units	3,621	0.899 (0.897-0.901)	1,741	0.772 (0.769-0.775)
> 14/21 units	749	0.916 (0.912-0.920)	177	0.772 (0.762-0.782)
p value		*<0.001*		*0.9620*
GHQ score				
≤ 4 units	3,152	0.901 (0.899-0.904)	1,202	0.775 (0.772-0.779)
≥ 5 units	1,218	0.904 (0.900-0.907)	635	0.766 (0.761-0.771)
p value		*0.319*		*0.007*

*Recommended maximum alcohol intake per week for men: 21 units and for women: 14 units

5.1.4 Linear regression analysis of BMI and WHR by social support and relationship status

The associations between social support, relationship status and BMI, WHR were not modified by gender, thus gender-adjusted analyses are presented. Emotional support was not significantly associated with BMI in the age-adjusted model (Model 1, Table 12). However once employment grade and ethnicity were adjusted for (Model 3) emotional support showed a positive association with BMI. The association became stronger when health behaviours were added to the model (Model 3) and in the fully adjusted model, those in the low tertile of emotional support had BMI lower by -0.29 (SE 0.11) kg/m^2 compared to those in the high tertile (Table 12). Practical support was positively associated with BMI in a dose-response manner in all models. In age and gender adjusted model (Model 1), participants in the low and medium tertile had lower BMI by -0.41 (SE 0.12) kg/m^2 and -0.38 (SE 0.12) kg/m^2, respectively. Adjusting Model 1 for grade and ethnicity did not attenuate the association and adjusting for health behaviours strengthened the association, such that being in the low tertile of practical support was associated with -0.53 (SE 0.12) kg/m^2 and being in the medium tertile of practical support was associated with -0.42 (SE 0.12) kg/m^2 lower BMI compared with the high tertile, p<0.001. There was no difference in BMI between participants in the first tertile of negative aspects of social support and those in the third tertile in all models. Participants in the second tertile of negative aspects of social support had lower BMI compared to those in the third tertile in all models, and adjusting for covariates in models 2, 3 and 4 attenuated the estimates of the association only very slightly

(medium tertile vs. high tertile -0.29 (SE 0.12) kg/m^2 in Model 1 and medium tertile vs. high tertile -0.26 (SE 0.12) kg/m^2 in Model 4). Single participants had lower BMI than married participants before and after adjustments (BMI of single participants was lower by -0.28 (SE 0.14) kg/m^2 in the age and gender adjusted model and by -0.36 (SE 0.13) kg/m^2 in the fully-adjusted model, p<0.01). Divorced/widowed participants had higher BMI than married counterparts (+0.46, SE 0.17 kg/m^2, p<0.01 in the basic Model 1), however this difference was partly attenuated by adjustment for employment grade and ethnicity and further attenuated by adjustment for health behaviours (+0.26, SE 0.17 kg/m^2; Table 12).

Emotional support was associated with WHR adjusting for employment grade and ethnicity and health behaviours, though not in the minimally adjusted model (Table 13). Low tertile, compared with high tertile, of practical support was associated with lower WHR in all models. In the fully-adjusted model, participants in the low tertile of practical support had WHR lower by -0.008 (SE 0.002) compared to those in the high tertile, p<0.001. Negative aspects of social support were positively associated with WHR though the association was not linear. In the fully-adjusted model, participants in the second tertile of negative aspects of social support had WHR lower by -0.004 (0.002) compared to those in the high tertile, p<0.05. Single participants had lower WHR than married participants before and after adjustments (WHR of single participants was lower by -0.007 (SE 0.002) in the fully-adjusted model, p<0.01). Divorced/widowed participants had higher WHR than married counterparts (+0.008 (SE 0.003) in the age- and gender- adjusting model, p<0.01), however after adjusting for health behaviours the association between WHR and divorce became non-significant (Table 13).

Descriptive characteristics of participants as well as results from linear regressions did not vary significantly between imputed and non-imputed datasets and can be found in the Appendix I.

Table 12 Multiply adjusted associations between social support and BMI, n=6,207. All exposures (social support variables and relationship status) were entered in separate models.

		BMI (kg/m^2)			
		Model 1 coefficient (SE) **+ age & gender**	Model 2 coefficient (SE) **+ grade & ethnicity**	Model 3 coefficient (SE) **+ health behaviours**	Model 4 coefficient (SE) **+ GHQ**
Emotional support					
Tertile 1 (low)	2,131	-0.22 (0.12)	-0.23 (0.11)*	-0.29 (0.11)*	-0.29 (0.11)*
Tertile 2	1,173	-0.11 (0.12)	-0.12 (0.11)	-0.12 (0.11)	-0.12 (0.11)
Tertile 3	1,903	Reference	reference	reference	reference
Practical support					
Tertile 1 (low)	2,279	-0.41 (0.12)***	-0.43 (0.12)***	-0.54 (0.12)***	-0.53 (0.12)***
Tertile 2	2,179	-0.38 (0.12)**	-0.37 (0.12)**	-0.42 (0.12)***	-0.42 (0.12)***
Tertile 3	1,749	reference	reference	reference	reference
Negative aspects					
Tertile 1 (low)	2,249	-0.18 (0.12)	-0.18 (0.12)	-0.11 (0.12)	-0.12 (0.12)
Tertile 2	2,195	-0.29 (0.12)*	-0.28 (0.12)*	-0.26 (0.12)*	-0.26 (0.12)*
Tertile 3	1,763	reference	reference	reference	reference
Relationship status					
Married/cohabiting	4,781	reference	reference	reference	reference
Single	905	-0.28 (0.14)*	-0.34 (0.14)*	-0.36 (0.13)**	-0.36 (0.13)**
Divorced/widowed	521	+0.46 (0.17)**	+0.34 (0.17)*	+0.26 (0.17)	+0.26 (0.17)

* p<0.05; ** p<0.01, *** p<0.001; Model 1: adjusted for gender, age; Model 2: Model 1 + employment grade and ethnicity (+ long standing illness in model with practical support); Model 3: Model 2 + health behaviours: smoking; alcohol consumption (units/wk.); fruit and vegetable consumption; mild, moderate and vigorous physical activity frequency; Model 4: Model 3 + GHQ (all covariates)

Table 13 Multiply adjusted associations between relationship status, social support and WHR, n=6,207. All exposures (social support variables and relationship status) were entered in separate models.

		WHR			
	n	Model 1 coefficient (SE) **+ age & gender**	Model 2 coefficient (SE) **+ grade & ethnicity**	Model 3 coefficient (SE) **+ health behaviours**	Model 4 coefficient (SE) **+ GHQ**
Emotional support					
Tertile 1 (low)	2,131	-0.003 (0.002)	-0.003 (0.002)	-0.005 (0.002)*	-0.005 (0.002)*
Tertile 2	1,173	-0.003 (0.002)	-0.003 (0.002)	-0.003 (0.002)	-0.003 (0.002)
Tertile 3	1,903	reference	reference	reference	reference
Practical support					
Tertile 1 (low)	2,279	-0.005 (0.002)**	-0.005 (0.002)*	-0.008 (0.002)***	-0.008 (0.002)***
Tertile 2	2,179	-0.002 (0.002)	-0.001 (0.002)	-0.003 (0.002)	-0.003 (0.002)
Tertile 3	1,749	reference	reference	reference	reference
Negative aspects					
Tertile 1 (low)	2,249	-0.006 (0.002)**	-0.003 (0.002)	-0.002 (0.002)	-0.002 (0.002)
Tertile 2	2,195	-0.007 (0.002)**	-0.005 (0.002)*	-0.004 (0.002)*	-0.004 (0.002)*
Tertile 3	1,763	reference	reference	reference	reference
Relationship status					
Married/cohabiting	4,781	reference	reference	reference	reference
Single	905	-0.006 (0.002)*	-0.006 (0.002)**	-0.007 (0.002)**	-0.007 (0.002)**
Divorced/widowed	521	+0.008 (0.003)**	+0.006 (0.003)*	+0.003 (0.003)	+0.003 (0.003)

* p<0.05; ** p<0.01, *** p<0.001; Model 1: adjusted for gender, age; Model 2: Model 1 + employment grade and ethnicity (+ long standing illness in model with practical support); Model 3: Model 2 + health behaviours: smoking; alcohol consumption (units/wk.); fruit and vegetable consumption; mild, moderate and vigorous physical activity frequency; Model 4: Model 3 + GHQ (all covariates)

5.2 Longitudinal analysis results

5.2.1 Descriptive analysis of participants included in the longitudinal analyses

Characteristics of the 5,773 participants included in the complete case longitudinal analysis were almost identical to those included in the cross-sectional analysis. For a full description and table of participants' characteristics see Appendix II. Table 14 shows mean BMI and WHR across the five phases for men and women included in the analytical sample (n=5,773). Mean BMI has been increasing over 15 years between phases 3 (1991-1994, ages 39-64) and 9 (2007-2009, ages 55-79) and was higher by approximately 1.4 kg/m^2 at phase 9 compared with phase 3. Mean BMI decreased at phase 11 (2012-2013, ages 59-83). Mean WHR has increased from 0.901 at phase 3 to 0.955 at phase 11 among men and from 0.769 at phase 3 to 0.836 at phase 11 among women.

Table 14 Mean BMI and WHR over follow-up phases 3 (1991-1994) to 11 (2012-2013), for observations included in the analytical sample (n=5,773)

P*	n	BMI	n	WHR: men		WHR: women
		Mean (95% CI)		Mean (95% CI)		Mean (95% CI)
3	5,478	25.22 (25.12-25.31)	3,862	0.901 (0.899-0.903)	1,557	0.769 (0.766-0.772)
5	4,463	26.12 (26.00-26.23)	2,876	0.923 (0.921-0.926)	1,192	0.796 (0.792-0.800)
7	5,104	26.67 (26.55-26.79)	3,681	0.941 (0.939-0.943)	1,429	0.815 (0.812-0.819)
9	4,912	26.72 (26.60-26.85)	3,569	0.942 (0.940-0.945)	1,345	0.822 (0.818-0.825)
11	4,468	26.64 (26.52-26.77)	3,266	0.955 (0.953-0.957)	1,201	0.836 (0.832-0.840)

***P= Phase**; 95% CI stands for 95% confidence interval

5.2.2 Trajectories of BMI and their associations with covariates

The data were consistent with nonlinear change in BMI and WHR over time. Maximum time of follow-up was 25.06 years. In the basic model, adjusting for baseline age and gender, baseline BMI (intercept) was 24.65 (SE 0.06) kg/m^2. The linear increase in BMI was 0.222 (SE 0.005) kg/m^2 per year but a negative coefficient for the quadratic term indicated that this slowed and became negative at later follow-up. BMI trajectories with 95% confidence intervals plotted separately for men and women are presented in Figure 8.

Figure 8 Body Mass Index trajectories with 95% confidence intervals for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773

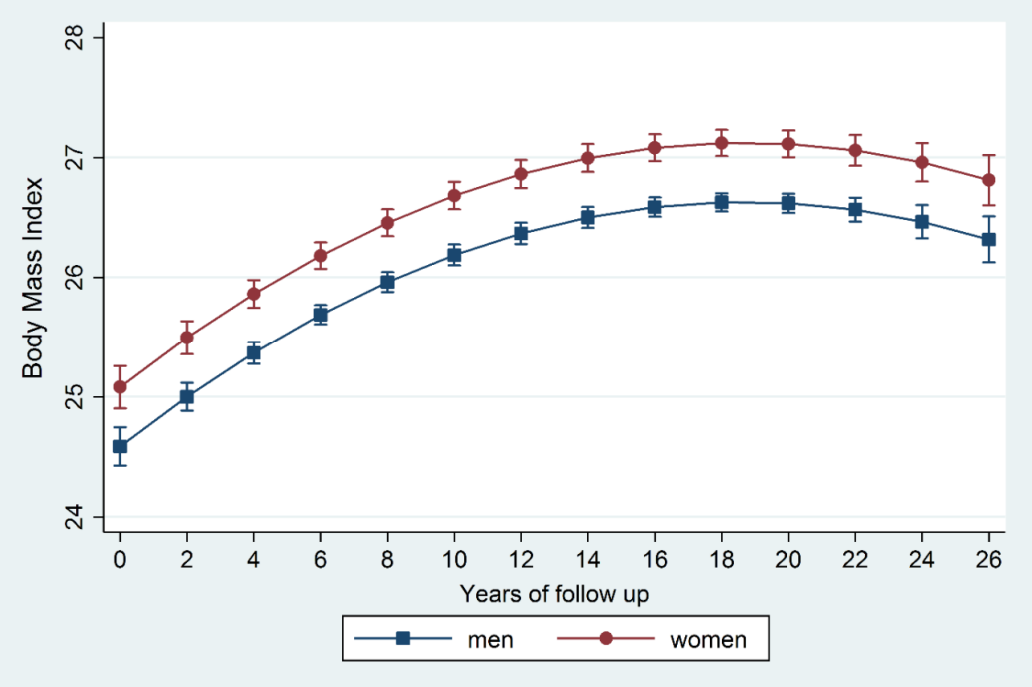


Table 15 shows BMI trajectories by covariates. At baseline, women had higher BMI levels and they also experienced a greater increase in BMI to around 20 years of follow-up. The gender by quadratic time interaction term indicates that women experienced a less steep increase and eventually a greater decrease in BMI at the end of follow-up compared with men. Interactions between all the other covariates and quadratic time were insignificant. Participants in professional and clerical employment grades had higher baseline BMI compared with participants in the (highest) administrative employment grade. Participants in clerical employment grade experienced additionally greater increase in BMI over the follow-up. Black African and Caribbean participants had higher baseline BMI compared with White participants, however the linear slope did not vary between these ethnic groups. South Asian participants did not vary from White participants in baseline BMI; however they experienced a less steep increase in BMI over time. Participants who reported not having a longstanding illness had lower baseline BMI compared with participants who reported having a longstanding illness, the linear BMI slope did not vary between these groups. Ex- and current smoking; nondaily fruit and vegetable consumption; and less than weekly mild, moderate and vigorous physical exercise frequency were associated with higher baseline BMI, however were not associated with BMI slope. Low alcohol intake (<14/21 units per week for women/men) was associated with lower baseline BMI as well as less steep BMI increase (Table 15).

Table 15 Trajectories of BMI by covariates, complete case analysis (n=5,773). All covariates measured at phase 2 (1989-1990).

Covariates	BMI		
	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient
Base model	24.65 (0.06)	0.222 (0.005)	-0.0057 (0.0001)
Women vs. men	+0.29 (0.12)**	+0.037 (0.010)***	-0.0011 (0.0004)***
Employment grade			
Administrative	reference	Reference	reference
Professional	+0.32 (0.11)**	+0.016 (0.010)	-0.0001 (0.0004)
Clerical	+1.03 (0.18)***	+0.032 (0.015)*	-0.0003 (0.0006)
Ethnicity			
White	reference	Reference	reference
South Asian	+0.17 (0.23)	-0.058 (0.023)*	+0.0008 (0.0008)
Black African & Caribbean	+2.53 (0.33)***	-0.027 (0.033)	-0.0010 (0.0013)
Other	+0.32 (0.64)	-0.089 (0.057)	+0.0029 (0.0021)
Longstanding illness			
Yes	reference	Reference	reference
No	-0.32 (0.11)**	-0.003 (0.009)	+0.0001 (0.0004)
Smoking status			
Never-smoker	reference	Reference	reference
Ex-smoker	+0.55 (0.11)***	+0.001 (0.010)	-0.00004 (0.00037)
Current	+0.39 (0.15)*	+0.023 (0.014)	+0.00087 (0.00055)
Freq. of fruit/veg			
<daily	reference	Reference	reference
daily+	-0.23 (0.11)*	-0.006 (0.009)	-0.0001 (0.0003)
Freq. of mild exercise			
3 times per week	reference	Reference	reference
Less frequent	+0.53 (0.11)***	+0.003 (0.009)	-0.0002 (0.0003)
Freq. of moderate exercise			
1-3 times per week	reference	Reference	reference
Less frequent	+025 (0.11)*	0.006 (0.009)	-0.0002 (0.0003)
Freq. of vigorous exercise			
1-3 time per week	reference	Reference	reference
Less frequent	0.63 (0.13)***	0.013 (0.011)	-0.0005 (0.0004)
Alcohol intake†			
High > 14/21 units	reference	Reference	reference
Low < 14/21 units	-0.63 (0.15)***	-0.026 (0.012)*	+0.0006 (0.0005)
GHQ score			
<4 (ref)	reference	Reference	reference
≥5	-0.02 (0.11)	+0.007 (0.010)	-0.0001 (0.0004)

* p<0.05; ** p<0.01; *** p<0.001; † Recommended maximum alcohol units per week for men: 21 units and for women: 14 units

5.2.3 Trajectories of WHR and their associations with covariates

In the basic model, adjusting for baseline age and gender, baseline WHR (intercept) was 0.890 (SE 0.001). The linear increase in WHR was 0.0049 (SE 0.0001) per year but a negative coefficient for the quadratic term indicated that this slowed and became negative at later follow-up. WHR trajectories with 95% confidence intervals plotted separately for men and women are presented in Figure 9.

Figure 9 Waist to hip ratio trajectories with 95% confidence intervals for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773 (complete case analysis)

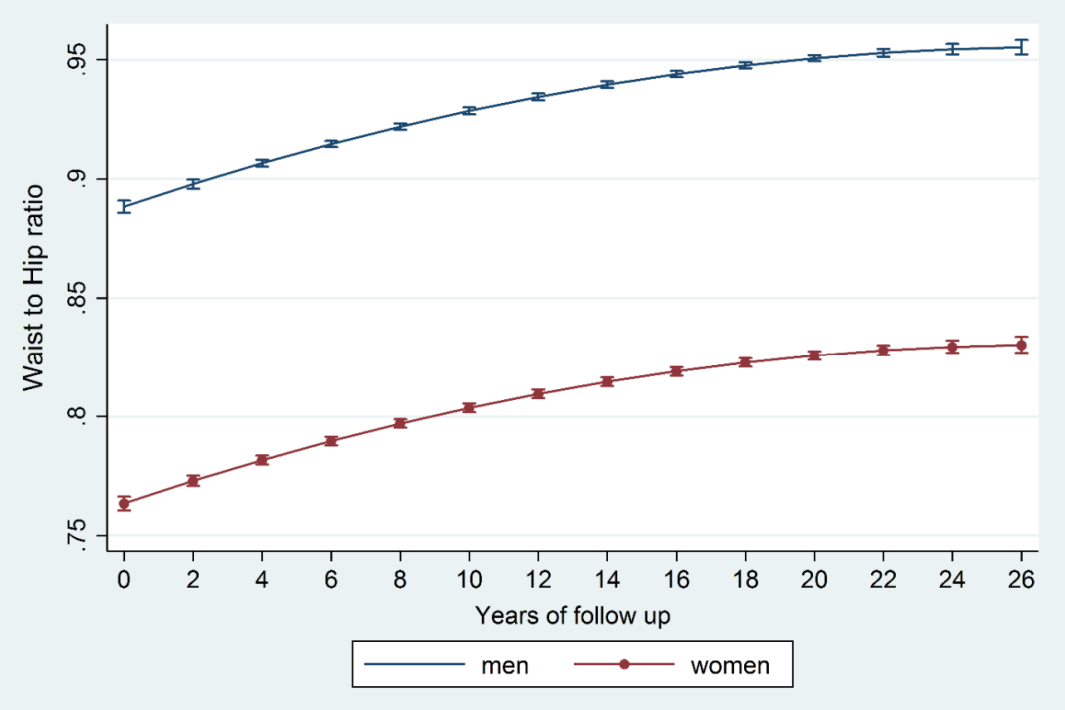


Table 16 shows WHR trajectories by covariates. Interaction terms between covariates and quadratic time did not improve the model fit and hence Table 16 shows only coefficients for WHR intercepts and linear slope. Participants in professional and clerical employment grades had higher baseline WHR compared with participants in the administrative employment grade, in addition to experiencing a greater increase in WHR. Women had lower WHR at baseline as well as less steep increase in WHR over the follow-up. Compared with White participants, South Asian, Black African and Caribbean participants had higher baseline BMI. South Asian participants also experienced a less steep WHR increase than White participants. Compared with those who reported a longstanding illness, participants without a

longstanding illness had lower WHR at baseline, yet a steeper WHR over time. Ex-smoking and current smoking status were associated with higher baseline WHR and current smoking was additionally associated with steeper WHR increase over the follow-up. Daily fruit and vegetable consumption was associated with lower WHR at baseline, however was not associated with WHR slope. Similarly, less frequent mild and moderate physical exercise was associated with higher baseline WHR, however was not associated with WHR slope. Weekly vigorous physical exercise was associated with lower WHR at baseline and steeper WHR increase over follow-up. Lastly, low alcohol intake was associated with lower WHR at baseline and was not associated with WHR slope (Table 16).

Table 16 Trajectories of WHR by covariates, complete case analysis (n=5,773). All covariates measured at phase 2 (1989-1990).

Covariates	WHR	
	Intercept coefficient	Linear slope coefficient
Base model	0.892 (0.001)	0.0045 (0.0001)
Women vs. men	-0.134 (0.002)***	-0.000074 (0.000004)***
Employment grade		
Administrative	reference	reference
Professional	+0.008 (0.002)***	+0.0002 (0.0001)*
Clerical	+0.022 (0.003)***	+0.0003 (0.0001)*
Ethnicity		
White	reference	reference
South Asian	+0.042 (0.004)***	-0.0010 (0.0001)***
Black African & Caribbean	+0.029 (0.006)***	-0.0005 (0.0003)
Other	+0.006 (0.010)	-0.0005 (0.0005)
Longstanding illness		
Yes	reference	reference
No	-0.008 (0.002)***	+0.0003 (0.0001)***
Smoking status		
Never-smoker	reference	reference
Ex-smoker	+0.012 (0.002)***	+0.00003 (0.00008)
Current	+0.019 (0.003)***	+0.00070 (0.00012)***
Freq. of fruit/veg		
<daily	reference	reference
daily+	-0.009 (0.0017)***	+0.00005 (0.00008)
Freq. of mild exercise		
3 times per week	reference	reference
Less frequent	+0.010 (0.002)***	-0.0001 (0.0001)
Freq. of moderate exercise		
1-3 times per week	reference	reference
Less frequent	+0.008 (0.002)***	-0.00001 (0.00008)
Freq. of vigorous exercise		
1-3 time per week	reference	reference
Less frequent	+0.019 (0.002)***	-0.0003 (0.0001)***
Alcohol intake†		
High > 14/21 units	reference	reference
Low < 14/21 units	-0.016 (0.002)***	+0.0002 (0.0001)
GHQ score		
<4 (ref)	reference	reference
≥5	-0.001 (0.002)	+0.0001 (0.0001)

* p<0.05; ** p<0.01; *** p<0.001; † Recommended maximum alcohol units per week for men: 21 units and for women: 14 units

5.2.4 Trajectories of BMI by level of social support and relationship status

Support, support by time and support by time squared interaction terms were added to allow trajectories to vary by social support tertile. Gender modified the associations between baseline social support, relationship status, and BMI trajectories: thus results are presented separately for men and women.

Emotional support was not associated with BMI at baseline and was negatively associated with linear BMI increase before and after adjusting for covariates (Table 17 and Figure 10) and the magnitude of the association was bigger in women. In the final fully adjusted models, men in the low tertile of emotional support had a steeper linear slope by +0.027 (SE 0.012) kg/m^2 compared to those in the high tertile, while women in the low tertile had a steeper slope by +0.042 (SE 0.027) kg/m^2 compared to those in the high tertile, however this difference did not reach statistical significance (Table 17). Women in the medium emotional support tertile had significantly steeper BMI than those with high emotional support. In other words, higher emotional support was associated with a less steep BMI gain in both men and women and the magnitude of the association was higher in women but was not linear (Table 17 and Figure 11). Practical support was associated only with baseline BMI in women. In the fully adjusted model, BMI of women in low or medium practical support tertiles was lower by -0.987 (SE 0.335) kg/m^2 and -1.148 (SE 0.353) kg/m^2 respectively compared with those in the high tertile. Low negative aspects of support in men were associated with a less steep BMI linear increase before and after adjustments for covariates (low tertile vs. high tertile -0.030, (SE 0.012) kg/m^2, $p<0.05$; Table 17 and Figure 11). Negative aspects of support were associated with BMI gain in women in a non-linear fashion. Compared with women in the high tertile of negative aspects of support, those in the low tertile had a steeper BMI slope by +0.021 (SE 0.026) kg/m^2 (however this difference did not attain statistical significance) and women in the medium tertile had steeper BMI slope by +0.060 kg/m^2 (SE 0.027), $p<0.05$ (Table17 and Figure 11). Relationship status was associated with BMI in men but not in women. Single men had lower baseline BMI (-0.047 (SE 0.163) kg/m^2, final model) and steeper linear BMI increase (+0.019 (SE 0.006), final model) compared with married men (Table 17 and Figure 12). Results for the remaining models: Model 2 (adjusting for Model 1 + employment grade and ethnicity) and Model 3 (adjusting for Model 2+ health behaviours) are presented in the Appendix III.

Table 17 Trajectories of BMI by social support over phases 3 (1991-1994) – 11 (2012-2013), complete case analysis, n=5,773. All exposures (social support variables and relationship status) were entered in separate models.

	BMI: men, n=4,118			BMI: women, n=1,655		
Model	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient
M1: Emotional support						
Tertile 1 (low)	-0.147 (0.131)	+0.029 (0.012)*	-0.0011 (0.0004)*	-0.306 (0.318)	+0.042 (0.027)	-0.0015 (0.0010)
Tertile 2 (medium)	-0.104 (0.132)	+0.030 (0.012)*	-0.0010 (0.0004)*	-0.087 (0.306)	+0.065 (0.026)*	-0.0017 (0.0001)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Emotional support						
Tertile 1 (low)	-0.236 (0.130)	+0.029 (0.012)*	-0.0011 (0.0004)*	-0.434 (0.312)	+0.042 (0.027)	-0.0015 (0.0010)
Tertile 2 (medium)	-0.128 (0.130)	+0.027 (0.012)*	-0.0010 (0.0004)*	-0.188 (0.300)	+0.065 (0.026)*	-0.0019 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Practical support						
Tertile 1 (low)	-0.039 (0.132)	-0.015 (0.011)	+0.0004 (0.0004)	-0.996 (0.339)**	-0.004 (0.029)	0.0002 (0.0011)
Tertile 2 (medium)	-0.017 (0.130)	0.002 (0.011)	-0.0005 (0.0004)	-1.186 (0.358)**	+0.033 (0.030)	-0.0012 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Practical support						
Tertile 1 (low)	-0.214 (0.131)	-0.015 (0.012)	+0.0004 (0.0004)	-0.987 (0.335)**	-0.003 (0.030)	+0.0002 (0.0011)
Tertile 2 (medium)	-0.068 (0.127)	0.002 (0.011)	-0.0005 (0.0004)	-1.148 (0.353)**	+0.031 (0.033)	-0.0012 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Negative aspects						
Tertile 1 (low)	-0.150 (0.133)	-0.030 (0.012)*	+0.0008 (0.0004)	-0.275 (0.315)	+0.021 (0.027)	-0.0005 (0.0010)
Tertile 2 (medium)	-0.341 (0.132)*	-0.015 (0.012)	+0.0005 (0.0004)	-0.436 (0.318)	+0.061 (0.027)*	-0.0018 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference

M4: Negative aspects						
Tertile 1 (low)	-0.183 (0.135)	-0.030 (0.012)*	0.0008 (0.0004)	-0.070 (0.319)	+0.021 (0.026)	-0.0005 (0.0010)
Tertile 2 (medium)	-0.365 (0.132)**	-0.015 (0.012)	0.0006 (0.0004)	-0.444 (0.315)	+0.060 (0.027)*	-0.0018 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.296 (0.161)	+0.019 (0.006)**	----	-0.215 (0.295)	+0.013 (0.011)	----
Divorced/widowed	+0.454 (0.220)	+0.003 (0.009)	----	+0.423 (0.336)	+0.016 (0.012)	----
M4: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.466 (0.163)**	+0.019 (0.006)**	----	-0.165 (0.294)	+0.013 (0.011)	----
Divorced/widowed	+0.240 (0.235)	+0.003 (0.009)	----	+0.252 (0.331)	+0.016 (0.013)	----

* <0.05; ** p<0.01; **M1: unadjusted model**: age at baseline; **M4**: all covariates (age at baseline, ethnicity, employment grade, health behaviours + GHQ)

Figure 10 Body Mass Index trajectories by emotional support for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773

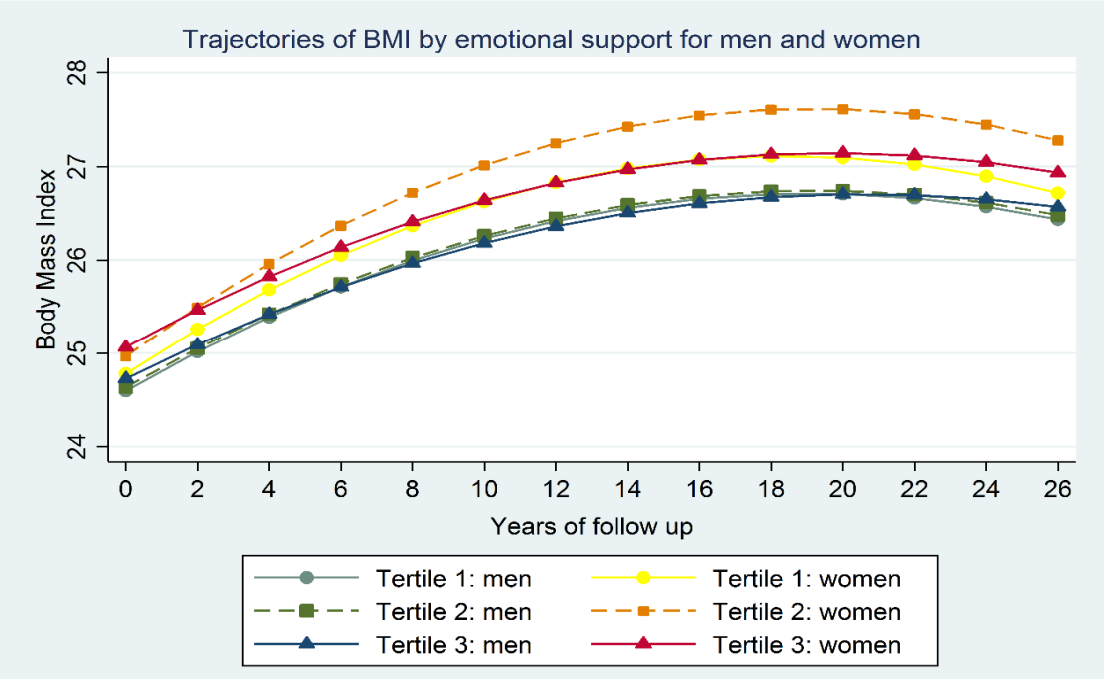


Figure 11 Body Mass Index trajectories by negative aspects of support for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773

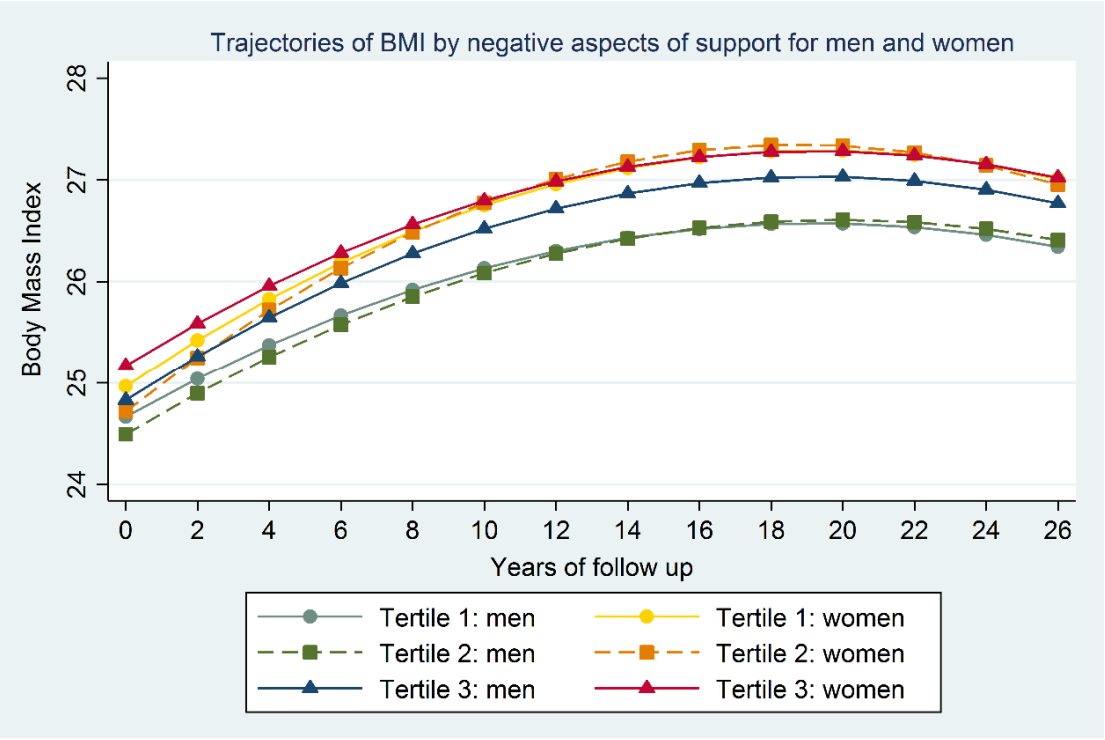
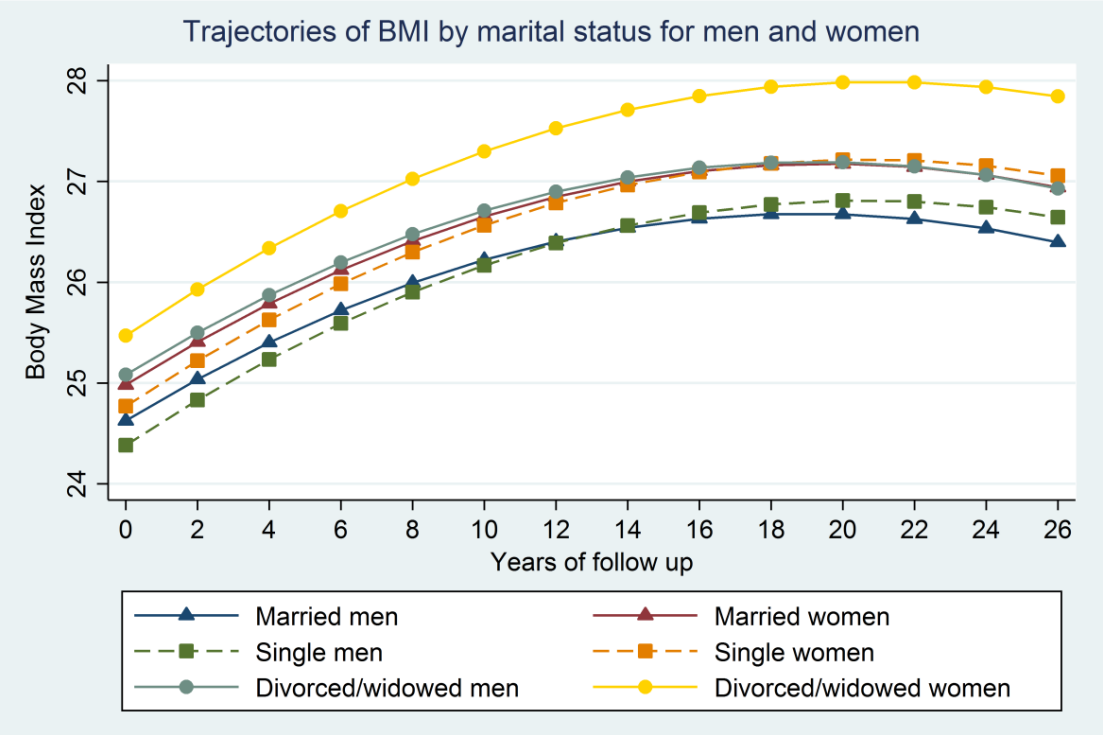


Figure 12 Body Mass Index trajectories by relationship status for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773



5.2.5 Trajectories of WHR by level of social support and relationship status

Support, support by time and support by time squared interaction terms were added to allow trajectories to vary by social support tertiles, but the latter did not improve the model fit for WHR and was not retained in the final WHR model. Gender modified the associations between baseline social support, relationship status and WHR trajectories: thus results are presented separately for men and women.

Emotional and practical support were not associated with WHR trajectories (Table 18). Being in the low tertile of practical support, compared with the high tertile, was associated with lower baseline WHR (-0.0094, SE 0.0047) in women in the age and gender adjusted model and lower baseline WHR (-0.0050, SE 0.0024) in men in the final model. In men, practical support was also weakly associated with WHR slope, with men in the medium tertile having less steep linear increase than those in the high tertile (-0.00025, SE 0.0001, final model). Negative aspects of support were associated with lower baseline WHR in the low (-0.0048, SE 0.0025, unadjusted model) and medium (-0.0081, SE 0.0025, $p<0.01$, unadjusted model) tertiles among men as well as in low (-0.0115, SE 0.0044, unadjusted model) and medium (-0.0102, SE 0.0044, unadjusted model) tertiles in women (Figure 13). Adjusting for

employment grade, ethnicity and health behaviours attenuated the difference in WHR intercepts between the low and high tertiles of negative aspects of support, while the difference between the medium and high tertiles remained. Men in the low tertile of negative aspects of support also experienced a less steep linear WHR increase (-0.00027, SE 0.00011, final model) compared to those in the high tertile. Single men compared to married had lower baseline WHR (-0.0105, SE 0.0031, final model) and steeper linear WHR increase (+0.0004, SE 0.0001, p<0.01, final model). Divorced/widowed men compared with married had higher baseline WHR, however this difference was attenuated in the fully-adjusted model. Divorced/widowed men had flatter linear WHR increase (-0.0004, SE 0.002, p<0.05, final model) compared to married men. Similarly, divorced/widowed women had flatter linear WHR increase (-0.0043, SE 0.00021, final model) when compared to married women (Table 18 and Figure 14). Results for the remaining models: Model 2 (adjusting for Model 1 + employment grade and ethnicity) and Model 3 (adjusting for Model 2 + health behaviours) are presented in the Appendix III.

Figure 13 Waist to hip ratio trajectories by negative aspects of support for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773

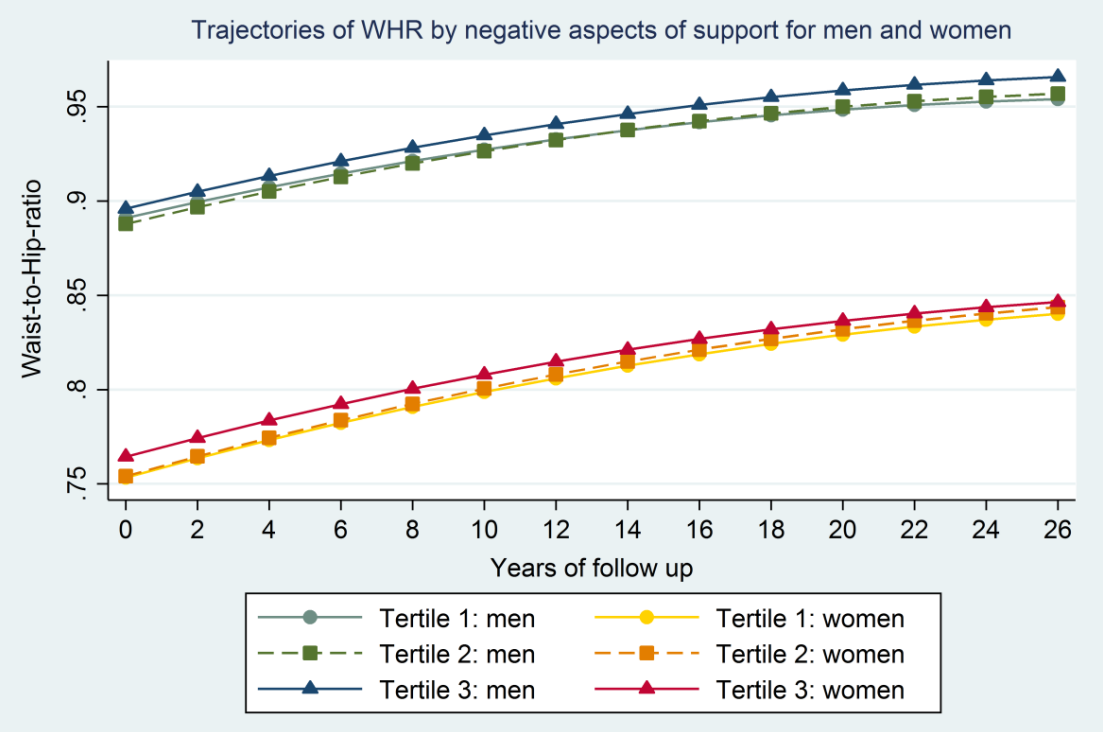


Figure 14 Waist to hip ratio trajectories by relationship status for men and women over up to 25 years of follow-up adjusted for baseline age, n=5,773

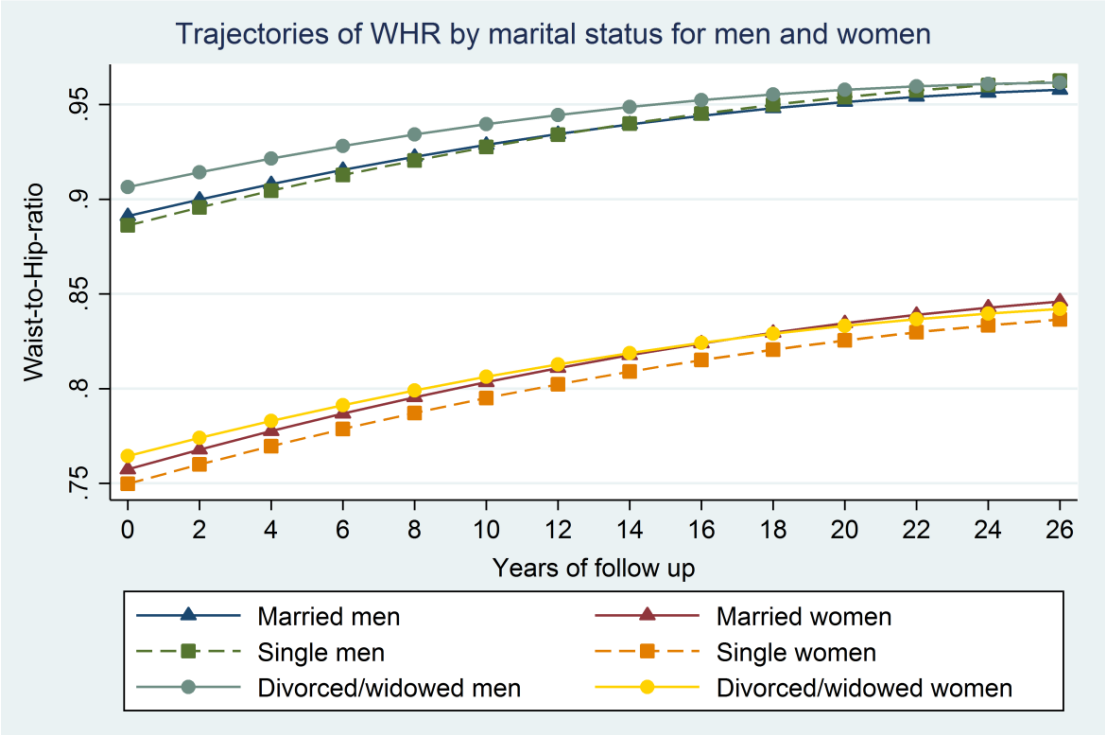


Table 18 Trajectories of WHR by relationship status and social support over phases 3 (1991-1994) – 11 (2012-2013), complete case analysis, n=5,773. All exposures (social support variables and relationship status) were entered in separate models.

	WHR: men, n=4,118		**WHR: women, n=1,655**	
Model	Intercept coefficient	Linear slope Coefficient	Intercept coefficient	Linear slope coefficient
M1: Emotional support				
Tertile 1 (low)	+0.0003 (0.0024)	+0.0002 (0.0001)	-0.0043 (0.0044)	+0.0001 (0.0002)
Tertile 2 (medium)	-0.0015 (0.0025)	+0.0001 (0.0001)	-0.0044 (0.0043)	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M4: Emotional support				
Tertile 1 (low)	-0.0025 (0.0024)	+0.0002 (0.0001)	-0.0050 (0.0043)	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0027 (0.0024)	+0.0001 (0.0001)	-0.0057 (0.0042)	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M1: Practical support				
Tertile 1 (low)	-0.0007 (0.0025)	-0.00004 (0.00011)	-0.0094 (0.0047)*	+0.0003 (0.0002)
Tertile 2 (medium)	+0.0028 (0.0023)	-0.00025 (0.00010)*	-0.0051 (0.0050)	+0.0001 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M4: Practical support				
Tertile 1 (low)	-0.0050 (0.0024)*	+0.00005 (0.00010)	-0.0090 (0.0046)	+0.00032 (0.00020)
Tertile 2 (medium)	+0.0013 (0.0023)	-0.00025 (0.00010)*	-0.0046 (0.0049)	+0.00008 (0.00022)
Tertile 3 (high)	reference	reference	reference	reference
M1: Negative aspects				
Tertile 1 (low)	-0.0048 (0.0025)*	-0.00027 (0.00011)*	-0.0115 (0.0044)**	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0081 (0.0025)**	-0.00003 (0.00011)	-0.0102 (0.0044)*	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference

M4: Negative aspects				
Tertile 1 (low)	-0.0022 (0.0024)	-0.00027 (0.00011)*	-0.0084 (0.0044)	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0058 (0.0024)*	-0.00003 (0.00011)	-0.0089 (0.0043)*	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M1: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0052 (0.0030)	+0.0004 (0.0001)**	-0.0077 (0.0043)	-0.00006 (0.00019)
Divorced/Widowed	+0.0153 (0.0044)**	-0.0004 (0.0002)*	+0.0067 (0.0049)	-0.00041 (0.00021)*
M4: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0105 (0.0031)**	+0.0004 (0.0001)**	-0.0030 (0.0042)	-0.00007 (0.00019)
Divorced/widowed	+0.0084 (0.0045)	-0.0004 (0.0002)*	+0.0061 (0.0048)	-0.00043 (0.00021)*

* <0.05; ** p<0.01; **M1: unadjusted model**: age at baseline; **M4**: all covariates (age at baseline, ethnicity, employment grade, health behaviours + GHQ)

Lastly, in order to rule out potential bias by relationship status transitions, growth curve models were fitted for the subset of participants who stayed in their relationship status over the whole of follow-up (Table 19). In the cohort and in the sample used for longitudinal analyses over 96% participants remained married, over 93% remained never married, while over 79% and 88% remained divorced and widowed. The new analytical sample size was n=4,049 and removing participants with relationship status transitions reduced the number of divorced/widowed participants (n=213). The results were in the same direction and, as expected, effect sizes were larger compared to models including all participants irrespective of relationship status transitions throughout the study. Divorced/widowed men had steeper BMI increase over time (+0.029 (SE 0.015) kg/m^2) as well as less steep linear WHR increase (-0.0006 (SE 0.0003), however these estimates were only borderline statistically significant, p=0.06. Divorced/widowed women also experienced a less steep WHR increase compared with married women (-0.0008 (SE 0.0003), $p<0.01$; Table 19. Results for the remaining models: Model 2 (adjusting for Model 1 + employment grade and ethnicity) and Model 3 (adjusting for Model 2+ health behaviours) are presented in the Appendix III.

Lastly, all the above analyses were also carried out on the imputed dataset (n=6,238). Since these analyses show the same findings, they are presented in the Appendix IV.

Table 19 Trajectories of BMI and WHR by relationship status, complete case analysis of participants who remain in their status category over phases 2-11, n=4,049.

		men n=3,038		**women n=1,011**	
BMI		Intercept Coefficient	Linear slope coefficient	Intercept coefficient	Linear slope coefficient
	M1: Relationship status				
	Married/cohabiting	reference	reference	Reference	reference
	Single	-0.42 (0.20)*	+0.024 (0.008)*	+0.04 (0.36)	-0.005 (0.013)
	Divorced/widowed	+0.88 (0.39)*	+0.029 (0.015)	+0.40 (0.45)	+0.010 (0.016)
	M4: Relationship status				
	Married/cohabiting	reference	reference	Reference	reference
	Single	-0.49 (0.20)*	+0.024 (0.008)**	+0.03 (0.36)	-0.004 (0.013)
	Divorced/widowed	+0.55 (0.38)	+0.029 (0.015)	+0.19 (0.44)	+0.010 (0.016)
WHR	**M1: Relationship status**				
	Married/cohabiting	reference	reference	Reference	reference
	Single	-0.008 (0.004)*	+0.0005 (0.0002)**	-0.001 (0.005)	-0.0003 (0.0002)
	Divorced/widowed	+0.031 (0.008)***	-0.0006 (0.0003)	+0.009 (0.006)	-0.0008 (0.0003)**
	M4: Relationship status				
	Married/cohabiting	reference	reference	Reference	reference
	Single	-0.011 (0.004)**	+0.0005 (0.0002)**	+0.002 (0.005)	-0.0004 (0.0002)
	Divorced/widowed	+0.019 (0.008)**	-0.0006 (0.0003)	+0.007 (0.006)	-0.0008 (0.0003)**

* p<0.05; ** p<0.01, *** p<0.001; **M1: unadjusted model**: age at baseline; **M4**: all covariates (age at baseline, ethnicity, employment grade, health behaviours + GHQ)

5.3 Summary of cross-sectional and longitudinal analyses results

Table 20 shows a summary of cross-sectional results obtained from the basic model adjusting for age and gender (Model 1) as well as the fully-adjusted model (Model 4). In the cross-sectional analyses there was no evidence of gender modification. Emotional support was positively associated with BMI and WHR at phase 3, however only once ethnicity, employment grade and health behaviours were adjusted for. Practical support and negative aspects of support were positively associated with BMI and WHR, both before and after adjustments for covariates. Single participants had lower BMI and WHR at phase 3 before and after adjustments for covariates compared with married participants. Divorced/widowed participants had higher BMI and WHR at phase 3 than married counterparts, however only before adjusting for health behaviours.

Table 20 Summary of cross-sectional results

Cross-sectional analysis results		
	BMI at phase 3 (**M1/M4**)	**WHR** at phase 3 (**M1/M4**)
Emotional support	0 / +	0 / +
Practical support	+ / +	+ / +
Negative aspects	+ / +	+ / +
Single vs. married	- / -	- / -
Divorced/widowed vs. married*	+ / 0	+ / 0

+ = **positive association**, p<0.05; **-** = **negative association**, p<0.05; **0** = **no association**

M1 = basic model adjusting for gender and age **/ M4** = fully-adjusted model adjusting for gender, age, ethnicity, employment grade, smoking, alcohol consumption, fruit and vegetable consumption, mild, moderate and vigorous physical activity frequency, GHQ

* models restricted to participants with stable relationship status categories over study period

Table 21 shows a summary of longitudinal results obtained from the basic model adjusting for age (Model 1) as well as fully-adjusted model (Model 4). In the longitudinal analyses gender modified the associations. Higher emotional support in men and women was associated with a less steep linear BMI increase before and after adjusting for covariates. Negative aspects of support were negatively associated with BMI gain in men. The association between negative aspects of support and BMI gain seemed less clear in women, and the high tertile of negative aspects was associated with flatter BMI linear slope compared

to the second tertile. Single men had lower baseline BMI in the fully-adjusted, but not the basic model, and steeper BMI increase both before and after adjustments compared with married men. In the analyses restricted to stable relationship status categories, divorced and widowed men had higher baseline BMI in the basic model and marginally steeper BMI slopes +0.029 before and after adjustments, p=0.06.

Emotional and practical support were not associated with WHR slope, except for men in the high tertile of practical support having a steeper linear increase than those in the medium tertile. In men, being in the low tertile of negative aspects of support compared with the high was associated with less steep linear WHR slope, i.e. less WHR gain over the follow-up period. Similarly to BMI models, compared with married men, single men had lower baseline WHR in the fully-adjusted model and steeper linear WHR increase before and after adjustments. Compared with married men, divorced/widowed men had higher baseline WHR before and after adjustments and experienced a less steep WHR increase (-0.0004, $p<0.05$ in the analysis, including the sample with relationship status changes and -0.0006, p=0.06 in the analyses restricted to participants with stable relationship status over time). Divorced/widowed women also experienced a less steep linear WHR increase compared to married counterparts (-0.00043, $p<0.05$ in the analysis including the sample with relationship status changes and -0.0008, $p<0.01$ in the analyses restricted to participants with stable relationship status over time).

Table 21 Summary of longitudinal results

Longitudinal analysis results: men				
Exposures (**M1** / **M4**)	**BMI** intercept	**BMI** gain	**WHR** intercept	**WHR** gain
Emotional support	0 / 0	- / -	0 / 0	0 / 0
Practical support	0 / 0	0 / 0	0 / +	+ / +
Negative aspects	+ / +	+ / +	+ / +	+ / +
Single vs. married	0 / -	+ / +	0 / -	+ / +
Divorced/widowed vs. married*	+ / 0	+ / +	+ / +	- / -

+ = **positive association**, $p<0.05$; **-** = **negative association**, $p<0.05$; **0** = **no association**

M1 = basic model adjusting for gender and age **/ M4** = fully-adjusted model adjusting for gender, age, ethnicity, employment grade, smoking, alcohol consumption, fruit and vegetable consumption, mild, moderate and vigorous physical activity frequency, GHQ

* models restricted to participants with stable marital status categories over study period

Longitudinal analysis results: women				
Exposures (**M1** / **M4**)	**BMI** intercept	**BMI** gain	**WHR** intercept	**WHR** gain
Emotional support	0 / 0	- / -	0 / 0	0 / 0
Practical support	+ / +	0 / 0	+ / 0	0 / 0
Negative aspects	0 / 0	- / -	+ / +	0 / 0
Single vs. married	0 / 0	0 / 0	0 / 0	0 / 0
Divorced/widowed vs. married*	0 / 0	0 / 0	0 / 0	- / -

+ = **positive association**, p<0.05; **-** = **negative association**, p<0.05; **0** = **no association**

M1 = basic model adjusting for gender and age **/ M4** = fully-adjusted model adjusting for gender, age, ethnicity, employment grade, smoking, alcohol consumption, fruit and vegetable consumption, mild, moderate and vigorous physical activity frequency, GHQ

* models restricted to participants with stable relationship status categories over study period

5.4 Discussion of results from cross-sectional and longitudinal analyses

The present study is the first to address the gap of person-level trajectories of WHR and BMI by social support and relationship status over midlife. This study demonstrates that social support and relationship status are associated with central and general adiposity cross-sectionally and longitudinally. The following discussion describes differences between cross-sectional and longitudinal models, the findings on the BMI and WHR trajectories by emotional support, negative aspects and relationship status, and concludes with other comments on findings and limitations of the studies.

5.4.1 Cross-sectional association social support/relationship status and BMI/WHR

Cross-sectionally, both emotional social support when adjusted for ethnicity, employment grade and health behaviours as well as marriage were associated with higher BMI and WHR. However, over time emotional social support and marriage may be protective for weight gain. The positive association between emotional support and BMI and WHR in cross-sectional analyses is unexpected. To the best of my knowledge, no previous study has found a positive association between emotional social support and weight. A possible explanation for this finding could be that emotional support in this study reflects marital relationship

quality, which has been positively associated with body weight in previous studies with short-term follow-up (Sobal, Rauschenbach and Frongillo, 1995; Meltzer et al., 2013). Over 77% of participants at phase 2 were married or cohabiting and 73% of all participants nominated their spouse or partner as the closest person who provided support to them. Alternatively, the short term effect of low social support on body weight could differ from the long term effect in a similar manner to those of affective symptoms and marital dissolutions. Previous study has demonstrated that women who experienced depression and anxiety as adolescents had initially lower BMI levels (at age 15); however their BMI increased faster throughout adulthood and was higher at age 53 (Gaysina et al., 2011). There is also evidence to suggest that weight changes following marital transition could be only short-term, especially in women (Averett, Sikora and Argys, 2008; Umberson, Liu and Powers, 2009; Wilson, 2012).

5.4.2 Longitudinal association social support/relationship status and BMI/WHR

In longitudinal models, the associations between social support/relationship status and BMI and WHR trajectories were modified by gender. Emotional support more than other subscales emerged as more related to BMI, confirming previous research suggests that the emotional dimension of support is central to benefits of support (Krause and Markides, 1990; Poulin et al., 2010; Morelli et al., 2015). High emotional support from the closest person was associated with a less steep BMI increase in men and women. Previous studies also found similar results. High positive aspects of support were associated with lower odds of 10% increase in BMI and WC (Kouvonen et al., 2011; Kershaw et al., 2014), while poor emotional support was associated with a higher risk of incident obesity among men, after adjusting for confounders such as age, social class, physical activity, alcohol consumption and smoking, but not among women (Oliveira et al., 2013). Here, high negative aspects of social support were associated with a steeper linear increase in BMI in men and women and a steeper linear increase in WHR slopes in men only. Negative aspects of social support were linked with higher odds of 10% increase in BMI and WC as well as greater mean increase in WC in previous studies, in both men and women (Kouvonen et al., 2011; Kershaw et al., 2014).

Findings on gender by social support and gender by relationship status interactions in the longitudinal models of BMI and WHR trajectories are in disagreement with previous studies (Umberson, Liu and Powers, 2009; Croezen et al., 2012; Rapp and Schneider, 2013; Kershaw et al., 2014; Mata, Frank and Hertwig, 2015; Teachman, 2016) which found no evidence of

effect modification by gender. Gender stratified models indicate that the association between negative aspects and emotional support was greater in magnitude for women in BMI models. However, these associations were not dose-response in women, as women in second tertiles of emotional support and negative aspects have steepest and flattest BMI slopes respectively. There is no previous evidence to suggest a U-shape association between emotional support or negative aspects and BMI in women. It is possible, however, that social support from the closest person used in this study does not adequately measure women's received social support, as women are consistently shown to have more extensive social ties and more sources of social support (Antonucci and Akiyama, 1987; Fuhrer et al., 1999; Fuhrer and Stansfeld, 2002). Studies of the Whitehall II participants showed that women receive more support from multiple close persons compared to men who tend to receive most of their support from the closest person, who tends to be the spouse (Fuhrer et al., 1999; Fuhrer and Stansfeld, 2002). Another study using the Whitehall II study data showed that low emotional support from the closest person was associated with common mental disorders, such as depression and anxiety, in men, but not in women (Stansfeld, Fuhrer and Shipley, 1998). Finally, the estimates for women are less precise, given the smaller sample size.

In the longitudinal models, relationship status was associated with BMI trajectories in men only. There was no association between BMI trajectories and relationship status in women unlike in many previous studies (Gallo et al., 2003; Averett, Sikora and Argys, 2008; Sobal and Hanson, 2011; Rapp and Schneider, 2013). In women, only divorce or widowhood was statistically associated with a slower increase in WHR compared with marriage. Thus, these findings disagree with reports of steeper BMI gain among widowed women compared with married women (Gallo et al., 2003), but are in line with findings of divorced/separated and widowed participants being lighter and more likely to lose weight than married participants (Umberson, 1992; Sobal, Rauschenbach and Frongillo, 2003; Averett, Sikora and Argys, 2008; Umberson, Liu and Powers, 2009; Wilson, 2012; Dinour et al., 2012; Rapp and Schneider, 2013). It is possible that in this population of mainly White collar office workers, marriage is less protective for women who are likely unrepresentative of women of this age in the general population. Previous studies suggest that protective effects of marriage on married women's longevity and risk of obesity compared with non-married seem to be mainly explained by wealth variables (Waite, 1995; Wilson, 2012). It is possible that divorced and widowed women in the Whitehall II study represent an affluent, more financially independent group who remain healthy and benefit from remaining non-married.

Present results confirm previous studies which report that cross-sectionally being married is associated with higher BMI than being single (Sobal, Rauschenbach and Frongillo, 1992, 2003; Heineck, 2006; The and Gordon-Larsen, 2009; Wilson, 2012; Mata, Frank and Hertwig, 2015; Teachman, 2016) and broaden them by demonstrating that being married or cohabiting is also associated with higher WHR. However, over time never-married men experienced steeper BMI and WHR increase, compared to their married/cohabiting counterparts. These findings are in agreement with previous studies by Ostbye et al. (2011) and Murayama et al. (2016), which reported that years in marriage and being married are associated with less steep BMI trajectories than non-marriage. They disagree with studies showing that marriage is associated with steeper BMI trajectories or greater weight gain than non-marriage (Newman et al., 2001; Averett, Sikora and Argys, 2008; Wilson, 2012; Schneider and Grimps, 2013; Teachman, 2016) or reporting no difference in BMI trajectories by marital status (Kahng, Dunkle and Jackson, 2004; Umberson, Liu and Powers, 2009). Comparison with previous studies is limited, as some of these studies grouped never married, divorced and widowed participants as non-married (Newman et al., 2001; Murayama et al., 2016); examined a younger population (Ostbye, Malhotra and Landerman, 2011; Teachman, 2016); or used a mainly US population, with one exception of a Japanese population.

Furthermore this study does not confirm that married or cohabiting participants are also heavier than divorced and widowed participants unlike other studies (Sobal, Rauschenbach and Frongillo, 2003; Averett, Sikora and Argys, 2008; Sobal and Hanson, 2011; Wilson, 2012; Teachman, 2016). On the contrary, here divorced and widowed men had higher baseline BMI and WHR than married ones, before adjustment for health behaviours. Additionally, divorced and widowed men compared with married counterparts had a steeper increase in BMI over time (in models analysing stable relationship trajectories), while at the same time experienced flatter trajectories of WHR. Previous studies have reported that WHR might be a superior measure of adiposity in ageing populations as it could capture an increase in abdominal fat when there is a simultaneous decrease in BMI (Kuk et al., 2009). Our results suggest that divorced and widowed men in this occupational cohort experience greater BMI gain and lower WHR gain over time when compared to married counterparts. When using WHR as a measure of adiposity, our results agree with findings of Sobal et al. (2003), that continuously divorced and widowed men experience weight loss compared to those in stable marriages and previous studies reporting that divorce and widowhood are associated with lower body weight and weight-loss (Averett, Sikora and Argys, 2008; Wilson, 2012; Dinour et al., 2012). In a comprehensive review on changes in eating behaviour associated with aging,

Elsner (2002) cites studies reporting loss of appetite following bereavement and suggests that meals, which were shared, bonding experiences with another person for many years, may be a painful remainder of the loss when consumed alone.

5.4.3 Explanatory pathways

Results from both cross-sectional and longitudinal analyses confirm the importance of health behaviours in the association between social support, relationship status and body weight. Adding health behaviours to the models attenuated and changed many associations. For example in cross-sectional analyses emotional support became statistically associated with BMI and WHR levels only after adjustment for health behaviours and in longitudinal analyses, BMI and WHR intercepts of divorced/widowed participant were almost halved by adding health behaviours to the models. Sobal and Nelson (2003) have also found that health behaviours drive the differences between marital transitions and weight change; for instance weight change of men who moved from being married to being divorced was explained by health behaviours. Indeed, this and other studies have shown that married, single and divorced individuals differ in health behaviours that have implications for body weight; for instance compared to marriage, divorce was linked to higher likelihood of smoking and physical inactivity as well as decreases in vegetable consumption in both men and women in previous studies (Eng et al., 2005; Lee et al., 2005). Despite previous evidence indicating that depressed mood or anxiety could mediate the association between social support and weight gain, this study does not find common mental disorder to be associated with BMI and WHR trajectories. These findings support conclusion from the review by Uchino et al. (2012) which states: “Inconsistent with existing theoretical models, no evidence was found that psychological mechanisms such as depression, perceived stress, and other affective processes are directly responsible for links between support and health” (Uchino et al., 2012, p.949).

Practical support was positively associated with BMI and WHR in cross-sectional analyses and BMI and WHR intercepts for women in longitudinal analysis. Men in the low tertile of practical support had lower baseline WHR when health behaviours are adjusted for and those in the second tertile have less steep WHR increase compared to those in the third tertile. Interpretation of practical support is challenging, as it is difficult to adjust for residual confounding of poor health and greater need for social support of those who report high received practical support (Uchino, 2009b). Previous study, also using the Close Persons

Questionnaire and the Whitehall II study data, reported better self-reported health in women in the low tertile of practical support compared to those in the high tertile (Fuhrer and Stansfeld, 2002).

5.4.4 Strengths and limitations

Strengths of this study include: a large sample size; an inclusion of formal tests of the modifying effect of gender; and addressing of the gap between person-level BMI and WHR trajectories by social support and relationship status over midlife in the UK population, using objectively-measured height, weight, waist and hip circumference. The majority of research on BMI trajectories so far comes from the United States, mainly from the Health and Retirement Study which uses self-reported heights and weights (Botoseneanu and Liang, 2011, 2012; Walsemann and Ailshire, 2011; Zajacova and Ailshire, 2014; Zajacova et al., 2015; Stenholm et al., 2015; He and Baker, 2004; Zheng, Tumin and Qian, 2013) as well as other US cohorts with self-reported measurements, such as Monitoring the Future Study (Clarke et al., 2009), Americans Changing Lives Study (Kahng, Dunkle and Jackson, 2004); Johns Hopkins Precursors Study (Barone et al., 2006), Duke Established Populations for Epidemiologic Studies of the Elderly (Kuchibhatla et al., 2013) and the National Longitudinal Survey of Youth 1979 (Averett, Sikora and Argys, 2008; Ostbye, Malhotra and Landerman, 2011; Teachman, 2016). Several other non-US studies on BMI trajectories also used self-reported height and weight data from cohorts such as FRENCH GAZEL study and The Swedish Annual Level of Living Survey (Dugravot et al., 2010; Caman et al., 2013). Self-reported measurements in the observational, particular longitudinal studies of body weight constitute a significant limitation of the current literature. Lastly, the follow-up of up to 25 years is one of the longest follow-up used to study trajectories of BMI by social support so far.

Some limitations of this study need to be acknowledged. This study analyses occupational cohort which is not representative of the general population, particularly of women of this generation. Missing observations were likely to report higher emotional support which could bias the results; however it would most likely lead to underestimation of the estimates. Participants who had missing information on social support and outcome were more likely to be older, work in lower employment grades and reported fewer beneficial health behaviours, such as less frequent fruit and vegetable intake and less frequent physical activity, in addition to reporting more smoking. As these variables are linked to both lower

social support and higher BMI/WHR, these missing observations could have biased the results, again most likely underestimating the estimates.

As covariates and social support variables included in these analyses were measured at phase 2, this study did not account for the change in these variables over time. Perceptions of social support are moderately stable over time (Sarason et al., 1986; Friedman et al., 2012). However it is not clear how much change there is in reports of social support from the closest person, especially over longer periods of follow-up. Kouvonen et al. (2011) have shown that negative aspects of closest relationships remain moderately stable between phase 1 and phase 2 (2.5 years) in the Whitehall II study, though social support levels are likely to vary over 25 years. Health behaviours and affective disorders are also likely to change over time.

Summary

Results from BMI and WHR models presented similar findings indicating that the associations between social support and weight are seen for both general and central adiposity. Cross-sectionally, social support and marriage were positively associated with BMI and WHR. Over time, emotional support, low negative aspects of support and being married were associated with better BMI and WHR trajectories. These associations were modified by gender, for instance the association between negative aspects of support and emotional support was greater in magnitude for women in BMI models, though they were not dose-response. The association between relationship status and BMI/WHR trajectories was only statistically significant in men, with the exception of divorced/widowed women having less steep WHR gain than married women.

The analyses presented in this chapter set out to assess the influence of functional and structural social support on the gradual increases in body weight that are the norm in the general population. It could not, however, examine if various aspects of social support are associated with weight loss and in the clinical population. The analyses presented in the next chapters investigate whether functional and structural social support is associated with weight loss from bariatric surgery. As these analyses necessitated primary data collection, they have also presented an opportunity to examine additional aspects of social support such as provided social support, quality of relationships and contact with friends and family. The next chapter describes the bariatric surgery patient population, data collection process and statistical analyses utilised to examine data on bariatric surgery patients.

Chapter 6 Analysis methodology of bariatric surgery patients data

This chapter describes data collection, development and administration of the questionnaire on social support to bariatric surgery patients, exposure and outcome measures, covariates, missing observations and statistical methods. These data were used to analyse the association between social support and weight loss following bariatric surgery.

6.1 Data collection and patient population

6.1.1 Research ethics and UCLH Bariatric Centre for Weight Management and Metabolic Surgery

This study was designed as a prospective cohort study and was part of a bigger research project, which received an ethical approval from Health Research Authority (ID#09/H0715/65). Inclusion of the questionnaire measuring patients' social support (Appendix V) was approved as an amendment to the ethical approval (version 5) on the 30th of September 2014 (Appendix VI). The study took place at the Bariatric Centre for Weight Management and Metabolic Surgery, University College London Hospital (UCLH), which is one of the largest centres in the UK with over 300 procedures carried out per year. Patients with severe obesity referred for consideration for bariatric surgery are assessed by members of a specialist multidisciplinary bariatric team that includes three specialist consultant surgeons, two consultant physicians, two clinical psychologists, two clinical nurse specialists, two specialist dieticians and bariatric anaesthetists. Three laparoscopic bariatric procedures are routinely offered to patients: gastric bypass (RYGB), sleeve gastrectomy (SG) and adjustable gastric band (AGB). The centre accepts GP referrals from GPs' across England as well as tertiary referrals from Gibraltar. The clinic follows NICE (2014) bariatric surgery eligibility guidelines (BMI of ≥40 kg/m^2, BMI of ≥35 with obesity-related co-morbidity or BMI <35 kg/m^2 with T2D diagnosed within the last 10 years).

Once a GP referral letter is received and accepted, patients are invited to take part in an education session explaining bariatric surgery procedures and required lifestyle changes. Within four weeks from the education session, the first clinic appointment "One-stop" is booked during which patients are assessed by the clinical nurse specialist, the dietician and consultant bariatric surgeon all within the same morning. Following the "One-stop" appointment, patients' suitability for surgery is evaluated by a multidisciplinary team made

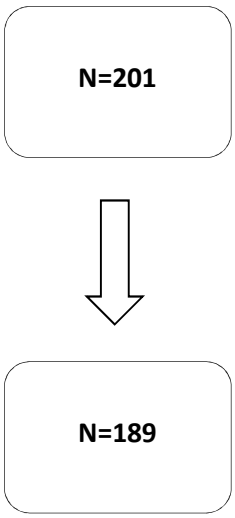
up of surgeons, physicians, clinical nurse specialists, dieticians, psychologists, and anaesthetists. Once the patients' suitability for surgery is discussed and if agreed by the multidisciplinary team, the patients are contacted by telephone and the second clinic appointment "Pre-Assessment" is booked by the bariatric pathway coordinator. Patients who are not ready for surgery are referred for further investigations/appointments in order to optimise their co-morbidities prior to surgery, for instance referral to see physician to control type 2 diabetes or to respiratory team to be assessed for obstructive sleep apnoea. These referrals defer the surgery by 6-12 months or more. Surgery usually occurs 6-12 weeks from the "Pre-Assessment" appointment. During the "Pre-Assessment" appointment patients see the clinical nurse specialist and the dietician who provides guidelines on the compulsory rapid pre-operative liver reducing diet. Patients are required to follow a liquid diet consisting of 4 x 295g of soup, 4 x 175g yogurts, 1 pint of semi-skimmed milk, a multi-vitamin tablet and a minimum of 4 pints of fluid (including water, tea, coffee and diet squashes) and for two weeks before the surgery. Following the surgery, patients are contacted by telephone within 7 days of surgery by the clinical nurse specialist, they then return to the clinic at: 4-weeks since surgery for a follow-up appointment with the clinical nurse specialist; 3 months since surgery for a follow-up appointment with the dietician; and 6 months since surgery for a follow-up appointment with the surgeon. Patients are followed up every 6 to 12 months thereafter. Patients' weight is measured at all pre- and post- surgery appointments as well as on the day of surgery. Timing of the post-operative follow-up appointments does not always fall at exactly 4 weeks, 3, 6, 12 and 24 months post-op due to primarily patients cancelling/postponing their appointments and in some instances due to clinic capacity. Patients who routinely fail to attend their post-op appointments are contacted by the clinic administrative manager in order to check on their progress and satisfaction with surgery.

6.1.2 Data collection

Patient recruitment for the study presented in this thesis took place three days per week between November 2014 and June 2015. Patients who were over 18 years old, with proficient English command and due to undergo gastric bypass or sleeve gastrectomy as primary procedures were approached by the researcher (Urszula Tymoszuk) during their "Pre-assessment" appointment and invited to participate in the study. Informed consent was obtained in person by myself accompanied by a healthcare professional (patient information sheet and consent form can be found in the Appendix VII. One hundred eighty nine patients from two hundred one approached (189/201=94%) agreed to take part in the study and

completed a 4-page questionnaire (Appendix V) while waiting for their pre-assessment appointments (Figure 15). Due to time constraints of this study (PhD timeline), patients who had undergone a surgery were followed up for up to 6 months post-surgery yielding three post-operative follow-up time points for analyses: **4 weeks**, **3 months**, **6 months post-surgery**.

Figure 15 Flow chart of the recruitment process.

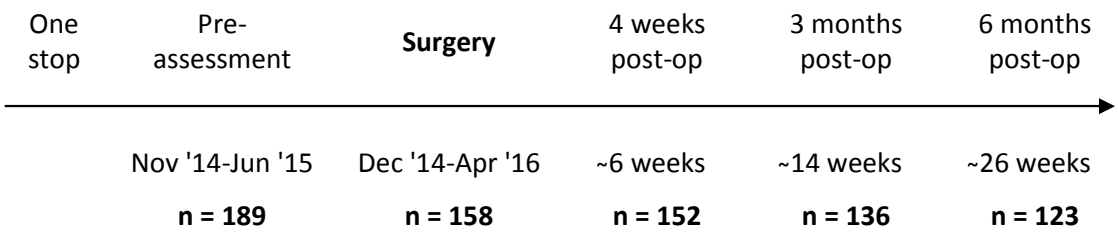


- ***201*** *bariatric surgery candidates were approached by the researcher between Nov 2014 and Jun 2015*
- ***12*** *(6%) of approached bariatric surgery candidates refused to participate in the study without giving a reason (n=10) or due to poor command of English language (n=2)*
- ***189*** *bariatric surgery candidates agreed to take part in the study (94% response rate)*

6.1.3 Recruited patients

The total number of patients recruited to the study between November 2014 and June 2015 was n=189 of which 158 had sleeve gastrectomy or gastric bypass (See Figure 16). Out of 158 patients who underwent the surgery, 152 attended the 4 weeks post-op appointment, 136 attended the 3 months post-operative appointment and 123 attended the 6 months post-operative appointment (Figure 16). Post-operative appointments did not always take place at exactly 4 weeks, 3 and 6 months. The first (4 weeks) post-operative follow-up appointment took place on average 6 weeks since surgery (median: 42.5 days, min. 19 - max. 75 days since surgery), the second (3 months) post-operative follow-up appointment took place on average 14 weeks since surgery (median: 95 days, min. 74 - max. 165 days since surgery), and the third (6 months) post-operative follow-up appointment took place on average 26 weeks since surgery (median: 184 days, min. 130 - max. 230 days since surgery; See Figure 1). These differences in timings of post-operative appointments were taken into account and adjusted for in the analyses (See Statistical analysis 6.5).

Figure 16 Clinical appointments schedule for bariatric surgery patients recruited in the study (n = 189) with the number of patients who had the surgery and attended each post-op follow-up appointment.



6.2 Questionnaire, exposure and covariates measures

6.2.1 Demographic data

Demographic data including date of birth, ethnicity and gender were obtained from the patient's clinical records. Ethnicity was recorded in UCLH patient clinical notes in 11 categories: "White British", "White Other", "White/Black Asian", "Mixed background", "Indian", "Other Asian", "Caribbean", "African", "Other Black background", "Other" and "Not stated" and was further categorised for analyses as: White British and other White ethnicities, Non-White ethnicities and Not stated. Education and paid employment status (currently in paid employment: yes vs. no) were asked in the questionnaire administered to patients. The education attainment scale was obtained from UK Household Longitudinal Study Wave 1 questionnaire and patients' answers were later categorised as: above A level, A level and below A level.

6.2.2 Functional and structural social support data

In order to capture diverse aspects of social support, various measures were included in the questionnaire (Appendix V).

6.2.2.1 Functional aspects of social support

Received social support from the closest person

To harmonise the social support scale used in the healthy population sample (the Whitehall II study) and the patients' sample, the same scale on receiving support from the closest person, the Close Persons Questionnaire, was used. The scale is described in more detail in the previous section 5.2.1. Briefly, patients were first asked to nominate a person they felt closest to in the last twelve months: "Partner/Spouse/Boyfriend/Girlfriend", "Friend", "Sibling", "Parent", "Child", "Other relative or acquaintance" and answered questions on emotional and practical support as well as negative aspects of support received from that person in the last 12 months. Three received support subscales displayed high to moderate internal validity in the patient sample respectively: Cronbach Alpha α=0.84 (received emotional support), Cronbach Alpha α=0.78 (received practical support), Cronbach Alpha α=0.64 (received negative aspects of support).

Provided social support

The Providing Social Support Questionnaire assesses social support provided in the last 12 months to friends, neighbours and relatives has been designed and validated by Krause and Markides (1990) and used in previous research (Krause, Herzog and Baker, 1992; Krause, 1995, 1999; Krause and Shaw, 2000; Liang, Krause and Bennett, 2001; Shaw et al., 2007). A revised version of the original questionnaire found in Krause (1995, 1999) and (Shaw et al., 2007) was used in this study. Patients were first asked to think about their relationships with their spouse or partner, friends, neighbours and other relatives and answer how much support they have provided to these close others in the last 12 months. Emotional support provided in the last 12 months was measured with 4 items, informational support provided in the last 12 months was measured with 3 items, practical support provided in the last 12 months was measured with 3 items; all were rated on a 4-point Likert scale scored as: "very often", "fairly often", "once in a while" and "never". Following an exploratory factor analysis (described in sections 6.5.1 and 7.1), emotional and informational support sub-scales were combined into one "provided emotional support" consisting of 7 items with high internal consistency Cronbach Alpha α=0.85. The provided practical support subscale displayed a moderate internal consistency, Cronbach Alpha α=0.75. Lastly, patients specified identity or

identities of persons to whom social support was provided: “Partner/Spouse/Boyfriend/ Girlfriend”, “Friend”, “Sibling”, “Parent”, “Child”, “Other relative or acquaintance”.

Relationship quality

Relationship quality was assessed with two questions on satisfaction with marital relationship and satisfaction with the relationship with the closest person (“All things considered how satisfied or dissatisfied are you with your marriage or partnership / with your relationships with the closest person?”). Answers to both questions were rated on a 7-point Likert scale: “very dissatisfied”, “moderately dissatisfied”, “little dissatisfied”, “no feelings either way”, “a little satisfied”, “moderately satisfied”, “very satisfied”.

6.2.2.2 Structural aspects of social support

Relationship status

Relationships status question asked about current relationship status and the four possible answers were: “single (never married)”, “married or in civil partnership or cohabiting”, “separated or divorced” and “widowed”.

Social contact

Social contact was assessed with two items: number of relatives seen once a month and number of friends and acquaintances seen once a month, both rated on a scale: “none”, “1-2”, “3-5”, “6-10”, “More than 10”.

6.2.3 Mediating pathways

Self-esteem and mastery were also included in the questionnaire as they were hypothesised to mediate associations between social relationships and weight change. The Rosenberg self-esteem scale of global self-esteem used in this study was developed in 1965 by Morris Rosenberg and is the most widely used scale of global self-esteem (Schmitt and Allik, 2005). It consists of 10 items rated on a 4-point scale “strongly agree”, “agree”, “disagree”, “strongly disagree” and has high internal consistency, Cronbach Alpha α=0.88 in the patient population. Mastery, one of the control constructs, similar to self-efficacy and sense of control, which measures the degree to which a person beliefs to have control over their life

(Pearlin and Schooler, 1978, p.5) was measured with the Pearlin Mastery Scale designed by Pearlin and Schooler (1978). This scale is one of the most commonly used scales aimed at measuring sense of mastery of one's life (DeSocio, Kitzman and Cole, 2003). It consists of 7 items rated on a 4-point scale "strongly agree", "agree", "disagree", "strongly disagree" and has moderate internal consistency, Cronbach Alpha α=0.79 in the patient population.

6.2.4 Cognitive piloting of questions

In order to test common understanding of questions and potential issues with them, cognitive piloting of questions with three bariatric surgery candidates was carried out. Three patients (a middle-aged man, a middle-aged woman and a woman in her early thirties) completed the questionnaires together with the researcher and provided their answers and reasoning behind them. There were no major questionnaire design problems and the main feedback from cognitive piloting, which was further also confirmed in frequent questions from other patients, was the problem with defining the closest person – *"Who have you felt closest to in the last 12 months? Please describe in terms of their relationship to you and* ***tick one****: Partner/Spouse/Boyfriend/Girlfriend*; *Friend*; *Sibling*; *Parent*; *Child*; *Other relative or acquaintance".* Patients found it difficult to choose only one closest person. However the suggestion to focus on the main source/provider of social support usually helped to narrow down the choice, especially if a patient wanted to include their child as the closest person. One exception was a patient who specified "God" as the closest person and source of support and therefore was not able to complete received social support scale. The male patient who took part in cognitive piloting also explained that he did not feel that the category "other relative" described his relationship with his cousin, whom the patient also considered to be his very good "friend" and "closer than a sibling".

Additional feedback received from patients completing the questionnaires indicated three other interpretational issues. Few patients have expressed that the question "*How many relatives do you see once a month or more?*" was difficult to answer, as it did not include contact with relatives via phone calls or video calling such as Skype. A few patients also indicated that they were not sure how to answer questions on received practical support: "*Did you need practical help from this person with major things? (e.g. look after you when ill, help with finances, children)?*"; "*Did the person give you practical help with major things?*"; "*Would you have liked more practical help with major things from this person?*"; "*Did this person give you practical help with small things when you needed it? (e.g. chores, shopping,*

watering plants). These patients considered themselves to be very self-reliant and self-sufficient and expressed that they do not expect to receive practical support from their closest person. Lastly, a question from the Providing Social Support Questionnaire "*In the last 12 months how often have you provided someone with some transportation?*" raised concerns among the patients who do not drive and who did not want to tick "Never" as their answer without explaining the reason behind it. These concerns are however general and not specific to bariatric surgery patients thus did not preclude from including these instruments in patient population. Limitations of these measures will be considered in the interpretation of results and in the section on study limitations.

6.3 Outcome measures

Weight in kilograms was measured using a Walkthrough Platform by a trained health professional during all pre- and post-operation appointments as well as on the day of surgery. Height in centimetres was measured using a stadiometer. Body mass index (BMI, kg/m^2) was calculated for each clinic appointment (pre-assessment, day of surgery, and 4 weeks, 3 months and 6 months post-operation). Additionally, a relative measure of post-operative weight loss – percentage weight loss (%WL) was calculated by subtracting weight at each post-operative follow-up appointment (4 weeks, 3 months, 6 months) from the weight on the day of surgery and expressing the differences as percentage of the weight on the day of surgery. For example, %WL at 4 weeks is calculated by dividing absolute kilograms lost between surgery and 4 weeks by the patient's date of surgery weight:

$$\%WL\ at\ 4\ weeks = \frac{date\ of\ surgery\ weight - 4\ weeks\ weight}{date\ of\ surgery\ weight} \times 100$$

Using both absolute and relative metrics of weight loss from gastric bypass and sleeve gastrectomy is recommended to assess bariatric surgery outcome, however %WL is often the preferred measure by health care professionals and patients, and has been demonstrated to be a superior relative metric of weight loss, as it is least likely to be affected by preoperative BMI level (the most salient indicator of post-operative weight loss; van de Laar, de Caluwé and Dillemans, 2011; Hatoum and Kaplan, 2013). Absolute measures such as BMI or kilograms are also recommended for studying bariatric surgery outcomes and goals (van de Laar, de Caluwé and Dillemans, 2011). Both %WL and BMI were used as bariatric surgery outcomes in this study.

6.4 Missing data

Out of all 189 patients recruited to the study, 7 patients were excluded from the analytical dataset: 2 patients never returned their questionnaires; 4 patients underwent a gastric band instead of gastric bypass or gastric sleeve; and one became pregnant few weeks after the surgery. Following these exclusions, analytical samples at each time point varied between max. n=181 and min. n=123 as 25 patients recruited to the study at pre-assessment did not undergo a surgery and those who had surgeries (n=157) did not always attend their follow-up appointments (DNA) or had missing information on weight in their clinical records (Table 22). Out of 157 patients who had the surgery, 111 attended all three post-op appointments, 34 patients missed one appointment, 10 missed two appointments and 2 patients missed all three appointments.

Table 22 Analytical sample size for each clinic appointment and number of missing observations at each time point due to missing weight observations or missed clinic appointment (DNA).

Clinic appointments	Analytical sample size	Missing weight or DNA
Pre-assessment	181	1
Day of surgery	155	2
4 weeks post-op	152	5
3 months post-op	136	21
6 months post-op	123	34

Additional 4 observations (missing observation in received social support and three missing observations in employment) were dropped from the final linear regression and BMI trajectories models.

6.5 Statistical analysis

Statistical analysis of data from bariatric surgery patients was undertaken to i) understand the factor structure of the instrument capturing provided social support (which has not previously been assessed in a clinical population and outside the US); ii) compare patients who did and did not undergo surgery as well as those who did and did not attend the post-operative follow-up appointments; iii) estimate the associations between social relationship exposures and weight loss.

6.5.1 Exploratory factor analysis of the Providing Social Support Questionnaire

The 10 self-reported items from the Providing Social Support Questionnaire (Krause and Markides, 1990) that constitute three subscales (provided emotional support, provided informational support and provided practical support) were analysed using factor analysis to capture a few common factors within the scale. Factors were identified following Kaiser Criterion (Eigenvalue >1) and a scree plot and extracted following an oblique (promax) rotation allowing them to be correlated. Factor loadings were reported and internal scale consistency was measured with Cronbach Alpha. The original factor structure of the Close Persons Questionnaire assessing received social support fitted the patient data well.

6.5.2 Analyses of bariatric surgery candidates who did not proceed to a bariatric surgery and non-compliers of post-operative follow-up appointments

Patients recruited to the study who did not undergo bariatric surgery (n=25) were analysed in terms of baseline (pre-assessment) BMI, social support measures and other covariates and compared to patients who did undergo a gastric bypass or gastric sleeve. Reasons for not having the surgery were also reported. Comparative analysis of baseline characteristics including BMI, social support measures and other covariates for patients who attended all post-operative follow-up appointments (n=111) and those who missed one (n=34) or more (n=12) appointments was carried out.

6.5.3 Descriptive analyses

Descriptive characteristics of the analytical dataset were reported first. Then, associations between %WL and covariates at each time points (4 weeks, 3 months and 6 months) were analysed using linear regression models. To account for differences in timings of post-operative follow-up appointments and potential bias they could introduce, the associations between weight loss outcomes and covariates were adjusted for days since surgery centred at 4 weeks (28 days), 3 months (84 days) and 6 months (168 days). Next, the associations between social support exposures and covariates were presented. Linear regression models were used to analyse the associations between received and provided social support and covariates. Chi Square tests were used for the remaining social support exposures: romantic relationship satisfaction, satisfaction with the closest person, relationship status and contact

with friends and relatives. Fisher exact corrections were applied where one or more cells had less than 5 individuals.

6.5.4 Social support and weight loss at each post-operative visit

To assess the associations between weight loss and social support measures at each postoperative follow-up time (4 weeks, 3 months and 6 months), %WL was used as the outcome of interest and analysed in a series of linear regression models. In the linear regression models of %WL, each exposure variable was analysed separately in a series of models adjusted for days since surgery centred at 4 weeks (28 days), 3 months (84 days) and 6 months (168 days) as well as age and gender (Model 1), additionally ethnicity and employment (Model 2) and additionally self-esteem and mastery (Model 3, to investigate the possible mediating role of self-esteem and mastery). Outliers were identified using scatter plots and residual statistics. Observations with large residuals and high leverage were removed in sensitivity analyses and kept in the main analyses as the outliers did not substantially alter the results.

6.5.5 Post-operative body mass index growth curves

The linear regression models described in 6.5.4 examine weight relative to baseline (surgery) weight at each visit. This can identify whether any association between social relationships and weight depends on time since the surgery. An alternative approach to analysing these data is to estimate within-person changes in weight or BMI across the whole follow-up period. This is a statistically efficient use of data, which can include data from those who do not have complete observations at each visit and is the same approach taken in section 4.6.2 in the Whitehall II study analyses. Unlike ordinary fixed-effects linear regression models which test the association between social relationships and mean %WL at each follow-up visit, mixed-effects models allow to examine BMI change over the whole follow-up at both within and between person levels. Mixed-effects models allow to generate separate intercepts (starting points of the curve) and slopes (shapes of the curve) for each participant and show deviations from the overall intercept and slope for each individual (Dallal et al., 2009). Person-level trajectories of post-operative BMI were estimated using multilevel linear models with measurement occasion nested within a patient. Time was measured as follow-up time in days since the day of surgery expressed in months for an ease of interpretation. The basic model included fixed terms for an intercept (capturing baseline BMI), a linear term

for time (capturing the linear change in BMI with each month of follow-up) and a quadratic term for time (capturing nonlinear change in BMI). Both intercepts and slopes were allowed to vary between individuals. Terms for support, support by time and support by time^2 were added to the model to test if BMI trajectories vary by social support exposures. Gender and age on the day of surgery were added to the basic model (Model 1). Confounding and mediating covariates were then adjusted for in an additive manner: ethnicity and employment (Model 2) and self-esteem and mastery (Model 3). Potential outliers were identified using a method appropriate for longitudinal data described by Welch et al. (2012) which takes into account individual-level standardised residuals. Removing outlier observations in sensitivity analyses did not alter the results, thus analyses on all available observations were presented.

Chapter 7 Results of bariatric surgery patients data analysis

The first three analyses address the Objective 4 of this thesis and measure the levels of social support given and received in the patient population. Firstly, the factor structure of providing social support scale was analysed in order to understand the validity of this instrument in the patient population. Secondly, comparative analyses of patients who did and did not undergo the surgery as well as patients who did and did not attend the post-operative follow-up appointments were carried out. Thirdly, characteristics of patients, their levels of social support and weight loss were described. In order to describe weight loss in these patients by level of social support measures (objectives 5 and 6), linear regression models of the association between social support measures and %WL at each post-operative follow-up visit as well as trajectories of BMI decline over the whole follow-up period by social support measures, both adjusting for confounding and mediating covariates, were presented.

7.1 Exploratory factor analysis of the Providing Social Support Questionnaire

According to Kaiser Criterion (Eigenvalue > 1) and the scree plot, two factors were identified and extracted: Factor 1 (Eigenvalue, $\lambda = 3.76$) and Factor 2 (Eigenvalue, $\lambda = 1.03$). As factors are likely to be correlated, oblique (promax) rotation was used and no cross-factor loadings were detected. All factor loadings were >0.40 (Table 23). Face validity supported combining informational and emotional subscales, which will be referred to as provided emotional support as questions on informational support involved expressing empathy and confiding. This consisted of 7 items with high internal consistency measured with Cronbach Alpha (α=0.85). New provided emotional support subscale was used in all analyses presented from this point onwards. The second factor captured practical support, which consisted of 3 items and displayed a moderate internal consistency (Cronbach Alpha α=0.75).

Table 23 Factor structure of Providing Social Support Questionnaire in patient data

Please answer: In the last 12 months how often have you…	Original subscales from Krause and Markides (1990)	Standardised factor loadings		Uniqueness
1. Provided someone with some transportation?	Provided practical support		0.59	0.68
2. Pitched in to help someone do something that needed to get done, like household chores or DIY?	Provided practical support		0.74	0.46
3. Helped someone with their shopping?	Provided practical support		0.73	0.51
4. Told someone what you did in a stressful situation that was similar to one they were experiencing?	Provided informational support*	0.41		0.70
5. Suggested some action that someone should take in order to deal with a problem they were having?	Provided informational support*	0.51		0.55
6. Given someone information that made a difficult situation clearer and easier to understand?	Provided informational support*	0.65		0.38
7. Comforted someone by showing them physical affection?	Provided emotional support*	0.55		0.71
8. Listened to someone talk about their private feelings?	Provided emotional support*	0.82		0.39
9. Expressed interest and concern in someone's well-being?	Provided emotional support*	0.81		0.40
10. Been right there with someone who was experiencing a stressful situation?	Provided emotional support*	0.78		0.44

* Provided informational and emotional support subscales were combined to create a new providing emotional support subscale (Cronbach α=0.85)

7.2 Analyses of patients who did and did not undergo a bariatric surgery as well as post-surgery appointment compliers and non-compliers

Reasons for not having the surgery were reported in patients' clinical records and included: patients changing their mind about the surgery (n=3), continuously cancelling appointments and thus getting discharged from the clinic list (n=3), being not fit for surgery mostly due to poor respiratory function or diabetes control (n=12) and waiting for additional tests and results (n=7), for example sleep apnoea test or additional blood tests.

Patients who had surgery (n=157) compared to those who were declined surgery/changed their minds (n=25) reported more received emotional and practical support and more provided practical support (Table 24). More men than women appeared to be declined surgery/change their minds about the surgery, p=0.08 (Table 24). Groups did not vary in age, ethnicity, education, employment, self-esteem, mastery, received negative aspects, and provided emotional support, relationship status, romantic relationship and close person's satisfaction, number of friends and relatives seen on a monthly basis and their BMI levels at the pre-assessment appointment.

Patients who attended all post-operative appointments (n=111) were older than those who missed one appointment (47.03 vs. 46.13, $p<0.05$) and those who missed two or all appointments (47.03 vs. 36.11 $p<0.01$, Table 25). The two groups did not vary otherwise (Table 25).

Table 24 Comparative characteristics of patients who underwent the surgery (n=157) and those who did not (n=25)

	Surgery, n=157 N (%)	**No surgery**, n=25 N (%)	**p**
Gender: Men	**42 (26.8)**	**11 (44.0)**	**0.08**
Age at pre-assessment; mean (SD)	45.81 (11.82)	49.46 (11.19)	0.15
White British & other White ethnicity	116 (72.9)	16 (64.0)	
Non-White ethnicities	27 (17.2)	4 (16.0)	
Not stated ethnicity	14 (8.9)	5 (20.0)	0.24
Education below A level	80 (51.3)	9 (36.0)	
A level and above	43 (27.6)	7 (28.0)	
First & higher degree	33 (21.2)	9 (36.0)	0.22
Employed: Yes vs. No	90 (58.1)	14 (58.3)	0.98
Self-esteem; mean (SD)	19.45 (5.90)	19.04 (5.87)	0.75
Mastery; mean (SD)	13.83 (3.47)	13.16 (3.45)	0.37
Received emotional support; mean (SD)	**16.85 (3.91)**	**14.36 (4.72)**	**0.005**
Received practical support; mean (SD)	**6.27 (2.62)**	**4.96 (2.96)**	**0.02**
Received negative support; mean (SD)	2.65 (2.74)	2.32 (1.95)	0.56
Provided emotional support; mean (SD)	13.05 (4.29)	12.88 (5.03)	0.86
Provided practical support; mean (SD)	**4.50 (2.46)**	**3.36 (2.25)**	**0.03**
Romantic relationship satisfaction			
A little satisfied and below	11 (12.2)	3 (25.0)	
Moderately satisfied	14 (15.6)	3 (25.0)	
Very satisfied	65 (72.2)	5 (50.0)	0.28
Satisfaction with closest person			
A little satisfied and below	16 (10.3)	3 (12.0)	
Moderately satisfied	27 (17.3)	7 (28.0)	
Very satisfied	113 (72.4)	15 (60.0)	0.40
Relationship status			
Married/in civil partnership/cohabiting	90 (57.3)	12 (48.0)	
Single	41 (26.1)	6 (24.0)	
Divorced/separated/widowed	26 (16.6)	7 (28.0)	0.38
Seeing relatives/month			
None	11 (7.0)	4 (16.0)	
1-5	78 (49.7)	10 (40.0)	
6+	68 (43.3)	11 (44.0)	0.28
Seeing friends and acquaintances			
None	10 (6.4)	2 (8.0)	
1-5	81 (51.6)	9 (36.0)	
6+	66 (42.0)	14 (56.0)	0.35
BMI at pre-assessment; mean (SD)	46.77 (7.56)	45.65 (7.45)	0.50

Table 25 Comparative characteristics of patients who attended all post-operative follow-up appointments (n=111) and those who missed one (n=34), two or all appointments (n=12).

	Attended all	**Missed one**	**Missed two+**	P
	N (%)	N (%)	N (%)	
Gender: Men	31 (27.9)	7 (20.6)	4 (33.3)	0.60
Age at pre-assessment; mean (SD)	47.03 (10.95)	**46.13 (14.06)**	**36.11 (9.49)**	<0.01
White British & other White ethnicity	82 (72.9)	24 (70.6)	10 (83.4)	
Non-White ethnicities	19 (17.1)	7 (20.6)	1 (8.3)	
Not stated	10 (9.0)	3 (8.8)	1 (8.3)	0.91
Education below A level	59 (53.2)	16 (48.5)	5 (41.7)	
A level and above	30 (27.0)	9 (27.3)	4 (33.3)	
First & higher degree	22 (19.8)	8 (24.2)	3 (25.0)	0.94
Employed: Yes vs. No	64 (58.2)	18 (54.5)	8 (66.7)	0.76
Self-esteem; mean (SD)	19.36 (5.86)	19.26 (6.41)	20.83 (5.02)	0.70
Mastery; mean (SD)	13.86 (3.51)	13.65 (3.62)	14.17 (2.76)	0.90
Received emotional support; mean (SD)	16.85 (4.02)	16.65 (3.80)	17.33 (3.39)	0.87
Received practical support; mean (SD)	6.41 (2.45)	5.85 (2.86)	6.25 (3.25)	0.55
Received negative support; mean (SD)	2.86 (2.88)	2.15 (2.24)	2.17 (2.66)	0.34
Provided emotional support; mean (SD)	12.89 (4.04)	13.03 (4.52)	14.58 (5.85)	0.43
Provided practical support; mean (SD)	4.51 (2.41)	4.15 (2.46)	5.42 (2.91)	0.31
Romantic relationship satisfaction				
A little satisfied and below	8 (11.6)	3 (18.8)	0	
Moderately satisfied	10 (14.5)	4 (25.0)	0	
Very satisfied	51 (73.9)	9 (56.3)	5 (100.0)	0.40
Satisfaction with closest person				
A little satisfied and below	13 (11.8)	2 (5.9)	1 (8.3)	
Moderately satisfied	19 (17.3)	7 (20.6)	1 (8.3)	
Very satisfied	78 (70.9)	25 (73.5)	10 (83.4)	0.75
Relationship status				
Married/in civil partnership	69 (62.2)	16 (47.1)	5 (41.7)	
Single	26 (23.4)	10 (29.4)	5 (41.7)	
Divorced/separated/widowed	16 (14.4)	8 (23.5)	2 (16.6)	0.35
Seeing relatives/month				
None	8 (7.2)	3 (8.8)	0	
1-5	56 (50.5)	16 (47.1)	6 (50.0)	
6+	47 (42.3)	15 (44.1)	6 (50.0)	0.88
Seeing friends/month				
None	5 (4.5)	5 (14.7)	0	
1-5	61 (55.0)	14 (41.2)	6 (50.0)	
6+	45 (40.5)	15 (44.1)	6 (50.0)	0.18
BMI at pre-assessment; mean (SD)	46.97 (7.61)	46.35 (7.83)	46.02 (6.77)	0.86

7.3 Descriptive analysis of bariatric surgery patients

Characteristics of patients and their pre- and post-operation mean BMI and mean weight loss are reported (Table 26 and 27). At pre-assessment, mean BMI was 46.62 kg/m^2 (SD 7.53) and 36.11 kg/m^2 (SD 6.67) at 6 months post-surgery. Mean %WL at 4 weeks, 3 months and 6 months was 8.86% (SD 3.35), 14.67% (SD 4.13) and 20.72% (SD 5.26) respectively (Table 26). BMI and %WL distribution at all time points was fairly normal with a slight positive, right-skew.

Table 26 Pre- and post-operation BMI and post-operation weight loss for all available observations.

Variables	N	Mean (SD)	Median (Min-Max)
BMI at pre-assessment	181	46.62 (7.53)	45.73 (33.08-79.25)
BMI at surgery	155	45.06 (7.25)	43.58 (31.41-74.63)
BMI at 4 weeks	152	41.05 (7.22)	39.70 (26.92-70.68)
BMI at 3 months	136	38.32 (6.50)	37.61 (25.20-66.79)
BMI at 6 months	123	36.11 (6.67)	35.03 (24.56-62.33)
% WL at 4 weeks	152	8.86 (3.35)	8.67 (-1.88-21.04)
% WL at 3 months	136	14.67 (4.13)	14.32 (5.53-29.37)
% WL at 6 months	123	20.72 (5.26)	21.21 (5.62-35.53)

At pre-assessment, the mean age was 46.31 years, 70.9% of patients were women and 72.5% were White British or White Other ethnicity (Table 27). Over twenty three percent of patients had first or higher degree education and 49.2% were educated below A level. Just over 58% of patients were in paid employment. Over 66% patients had normal self-esteem and 14.2% had high self-esteem. Median mastery was 14 (min. 4 – max. 21). Out of all recruited patients (n=182), 157 (86.5%) proceeded to have one of the two bariatric procedures: gastric bypass (n=52, 33.1%) or gastric sleeve (n=105, 66.9%).

Table 27 Descriptive characteristics of all recruited patients, max. n=182**.**

Variables	**N/%**
Gender	
Men	53 (29.1)
Women	129 (70.9)
Age at recruitment (pre-assessment)	46.31 (11.77)
Ethnicity	
White British & other White	132 (72.5)
Non-White ethnicities	31 (17.0)
Not stated	19 (10.4)
Education	
Below A level	89 (49.2)
A level and above	50 (27.6)
First & higher degree	42 (23.2)
Employed	
Yes	104 (58.1)
No	75 (41.9)
Self-esteem; median (min.-max.)	20 (5-30)
Low <15	36 (19.7)
Normal 15-25	121 (66.1)
High 25-30	26 (14.2)
Mastery; median (min.-max.)	14 (4-21)
Tertile 1	62 (34.1)
Tertile 2	73 (40.1)
Tertile 3	47 (25.8)
Surgery status	
Surgery	157 (86.3)
No surgery	25 (13.7)
Surgery type	
RYGB	52 (33.1)
SG	105 (66.9)
	N/% or mean (SD) / median (min-max.)
Functional social support	
Received emotional support	16.50 (4.11) / 18 (1-21)
Received practical support	6.09 (2.68) / 6 (0-9)
Received negative support	2.61 (2.64) / 2 (0-12)
Provided emotional support	13.03 (4.39) / 13 (0-21)
Provided practical support	4.35 (2.46) / 4 (0-9)
Romantic relationship satisfaction	
A little satisfied and below	14 (13.7)
Moderately satisfied	17 (16.7)
Very satisfied	71 (69.6)

Satisfaction with closest person	
A little satisfied and below	19 (10.5)
Moderately satisfied	34 (18.8)
Very satisfied	128 (70.7)
Structural social support	
Relationship status	
Married/in civil partnership/cohabiting	102 (56.0)
Single	47 (25.8)
Divorced/separated/widowed	33 (18.2)
Seeing friends/month	
None	12 (6.6)
1-5	90 (49.4)
6+	80 (44.0)
Seeing relatives/month	
None	15 (8.2)
1-5	88 (48.4)
6+	79 (43.4)

Functional and structural support levels of bariatric surgery patients are also described in Table 27 and compared with the Whitehall II study participants in Table 28. Median received emotional support was 18 out of 21, median received practical support was 6 out of 9 and median received negative support was 2 out of 12. Median provided emotional support was 13 out of 21 and median provided practical support was 4 out of 9. Compared with the Whitehall II participants, patients appeared to have higher median received emotional support (18 vs. 15.5), slightly higher median received practical support (6 vs. 5.5) and slightly lower median received negative aspects (2 vs. 2.5). In the patient sample, 69.6% of patients with romantic partners report being very satisfied with their relationship and 70.7% report being very satisfied with their relationship with the closest person. Fifty six percent were married, in civil partnership or cohabiting, 25.8% of patients were single (never-married) and 18.2% of patients were divorced/separated/widowed. Over 8% of patients reported seeing no relatives per month and 6.6% of patients reported seeing no friends on a monthly basis.

Table 28 Comparison of received social support levels among patients and the Whitehall II study participants included in the analyses.

	Bariatric surgery patients	**The Whitehall II study participants**
	mean (SD) / median (min.- max.)	
Received emotional support	16.50 (4.11) / 18 (0-21)	15.09 (4.03) / 15.5 (0-21)
Received practical support	6.09 (2.68) / 6 (0-9)	5.45 (2.55) / 5.5 (0-9)
Received negative aspects	2.61 (2.64) / 2 (0-12)	2.79 (2.11) / 2.5 (0-12)
Relationship status		**N (%)**
Married/cohabiting	102 (56.0)	4,781 (77.0)
Single	47 (25.8)	905 (14.6)
Divorced/widowed	33 (18.2)	521 (8.4)

7.3.1 Association between weight loss and covariates among bariatric surgery patients

Higher %WL was associated with younger age (at 3 months post-surgery), with White British and other White ethnicities (at 3 and 6 months post-surgery) and paid employment (at 4 weeks and 3 months post-surgery), $p<0.05$. Higher %WL was also associated with high self-esteem (at 4 weeks post-surgery; Table 29). The association between BMI at all four (including day of surgery) time points and covariates can be found in the Appendix VIII. Briefly, no covariates were associated with BMI at any time points with exception of self-esteem which was negatively associated with BMI at all time points.

Table 29 Percentage weight loss by covariates at: 4 weeks (n=152), 3 months (n=136) and 6 months (n=123). All variables except surgery type were collected at pre-assessment.

		4 weeks			**3 months**			**6 months**	
	N	**Coeff. (SE)**	**P**	**N**	**Coeff. (SE)**	**p**	**N**	**Coeff. (SE)**	**p**
Gender: Men	41	reference		38	reference		32	reference	
Women	111	-0.53 (0.56)	0.44	98	-0.10 (0.75)	0.89	91	+0.11 (1.09)	0.92
Age at surgery	152	-0.02 (0.02)	0.33	136	**-0.06 (0.03)**	**0.043**	123	-0.05 (0.04)	0.23
Surgery type									
RYGB	51	reference		44	reference		39	reference	
SG	101	-0.37 (0.52)	0.55	92	-0.68 (0.72)	0.34	84	-1.79 (1.02)	0.08
Ethnicity									
White British & other White **(ref)**	113	reference		99	reference		90	reference	
Non-White ethnicities	26	-0.75 (0.66)	0.25	24	**-1.75 (0.88)**	**0.050**	22	**-2.53 (1.24)**	**0.043**
Not stated	13	+1.28 (0.88)	0.15	13	+1.16 (1.14)	0.31	11	-0.05 (1.66)	0.98
Education									
Below A level **(ref)**	78	reference		70	reference		66	reference	
A level and above	41	-0.59 (0.59)	0.32	37	-0.90 (0.80)	0.26	32	-0.16 (1.14)	0.89
First & higher degree	32	-0.27 (0.64)	0.68	29	-0.22 (0.87)	0.80	24	+0.65 (1.27)	0.61
Employment: Yes	88	reference		77	reference		70	reference	
No	62	**-1.38 (0.50)**	**0.006**	57	**-1.54 (0.68)**	**0.025**	52	-0.92 (0.96)	0.34
Self-esteem									
Low <15 **(ref)**	31	reference		27	reference		24	reference	
Normal 15-25	100	+1.02 (0.62)	0.10	91	+1.43 (0.86)	0.10	82	+0.80 (1.23)	0.52
High 25-30	21	**+1.81 (0.85)**	**0.03**	18	+1.76 (1.18)	0.14	17	+0.54 (1.67)	0.75
Mastery									
Tertile 1	51	reference		47	reference		38	reference	
Tertile 2	61	+0.36 (0.58)	0.53	51	**+1.56 (0.79)**	**0.05**	50	+1.93 (1.12)	0.09
Tertile 3	40	+0.74 (0.64)	0.25	38	+0.83 (0.85)	0.33	35	-0.30 (1.22)	0.81

7.3.2 Association between social relationship exposures and covariates

Received emotional support was positively associated with self-esteem and mastery. Received negative aspects of support were higher among those from non-White ethnic groups and were negatively associated with mastery (Table 30). Provided emotional support varied by gender and age. Provided emotional support was higher in women (+1.93, SE 0.70) p=0.007) and negatively associated with age (Table 31). Romantic relationship satisfaction varied by mastery with those reporting high satisfaction having higher mastery than those with moderate satisfaction (Table 32). Satisfaction with the closest person, received practical support and provided practical support did not vary by any covariates. Married, cohabiting and those in civil partnership were older than single patients (47.52 vs. 38.53) and younger than divorced/widowed patients (53.64). Divorced and widowed patients were also more likely to be unemployed compared to those married, cohabiting or in civil partnership. Patients who reported seeing more friends on a monthly basis were more likely to have normal self-esteem compared to those who reported seeing no friends (Table 33). Patients who reported seeing more relatives on a monthly basis (1-5 and 6+) were more likely to report qualifications below A level as their highest educational attainment (Table 34).

Table 30 Covariates by received social support, max n=182. All variables were collected at pre-assessment.

		Received emotional support		**Received practical support**		**Received negative support**	
	N	Coefficient (SE)	p	Coefficient (SE)	p	Coefficient (SE)	p
Gender							
Men	53	16.36 (0.57)		6.00 (0.37)		2.25 (0.36)	
Women	128	+0.20 (0.67)	0.76	+0.13 (0.44)	0.78	+0.51 (0.43)	0.24
Age at pre-assessment	181	-0.04 (0.03)	0.10	+0.02 (0.02)	0.19	0.02 (0.02)	0.32
Ethnicity							
White British & other **(ref)**	132	16.43 (0.36)		6.02 (0.23)		2.30 (0.23)	
Non-White ethnicities	30	-0.13 (0.83)	0.87	+0.79 (0.54)	0.15	**+1.27 (0.53)**	**0.017**
Not stated	19	+0.88 (1.01)	0.38	-0.48 (0.66)	0.47	0.97 (0.64)	0.13
Education							
Below A level **(ref)**	89	16.94 (0.44)		6.21 (0.29)		2.57 (0.28)	
A level and above	49	-0.88 (0.73)	0.23	-0.35 (0.48)	0.48	-0.19 (.047)	0.70
First & higher degree	42	-0.75 (0.77)	0.33	-0.08 (0.51)	0.87	0.36 (0.50)	0.48
Employment							
Yes	104	16.76 (0.40)		5.80 (0.26)		2.55 (0.26)	
No	74	-0.62 (0.63)	0.32	+0.67 (0.41)	0.10	+0.13 (0.40)	0.75
Self-esteem							
Low <15 (**ref**)	35	14.94 (0.67)		5.91 (0.46)		2.49 (0.44)	
Normal 15-25	120	**+1.47 (0.76)**	**0.055**	+0.26 (0.52)	0.58	+0.37 (0.50)	0.46
High 25-30	26	**+4.10 (1.02)**	**<0.001**	+0.05 (0.70)	0.91	-0.87 (0.68)	0.20
Mastery							
Tertile 1 **(ref)**	62	14.94 (0.50)		6.19 (0.34)		3.13 (0.33)	
Tertile 2	73	**+1.95 (0.68)**	**0.005**	-0.10 (0.47)	0.86	-0.44 (0.45)	0.33
Tertile 3	46	**+3.06 (0.77)**	**<0.001**	-0.24 (0.53)	0.68	**-1.35 (0.51)**	**0.009**

Table 31 Covariates by provided social support, max n=182. All variables were collected at pre-assessment.

		Provided emotional support		**Provided practical support**	
	N	Coeff. (SE)	p	Coeff. (SE)	p
Gender					
Men	53	11.66 (0.59)		4.45 (0.34)	
Women	129	**+1.93 (0.70)**	**0.007**	-0.15 (0.40)	0.71
Age	182	**-0.06 (0.03)**	**0.032**	-0.01 (0.02)	0.55
Ethnicity					
White British & other **(ref)**	132	12.74 (0.28)		4.32 (0.22)	
Non-White ethnicities	31	+1.06 (0.88)	0.23	+0.33 (0.49)	0.51
Not stated	19	+0.99 (1.08)	0.36	-0.27 (0.61)	0.66
Education					
Below A level **(ref)**	89	12.49 (0.46)		4.39 (0.26)	
A level and above	50	+0.73 (0.78)	0.35	+0.07 (0.44)	0.88
First & higher degree	42	+1.39 (0.82)	0.09	-0.35 (0.46)	0.46
Employment					
Yes	104	12.96 (0.43)		4.5 (0.24)	
No	75	+0.09 (0.66)	0.89	-0.39 (0.37)	0.29
Self-esteem					
Low <15 **(ref)**	35	13.46 (0.74)		3.74 (0.42)	
Normal 15-25	121	-0.29 (0.84)	0.73	+0.79 (0.47)	0.09
High 25-30	26	-1.65 (1.13)	0.15	+0.53 (0.64)	0.41
Mastery					
Tertile 1 **(ref)**	62	12.97 (0.56)		3.87 (0.31)	
Tertile 2	73	+0.32 (0.76)	0.68	**+0.88 (0.42)**	**0.038**
Tertile 3	47	-0.27 (0.85)	0.76	+0.47 (0.47)	0.32

Table 32 Covariates by romantic relationship satisfaction in those with romantic partners (max n=102) and satisfaction with the closest person, max n=182. All variables were collected at pre-assessment.

	Romantic relationship satisfaction			**Satisfaction with the closest person**		
	Little (ref)	**Moderate**	**High**	**Little (ref)**	**Moderate**	**High**
	n=14	**n=17**	**n=71**	**n=19**	**n=34**	**n=128**
	%	%	%	%	%	%
Gender						
Men	28.6	29.4	35.2	42.1	29.4	27.3
Women	71.4	70.6	64.8	57.9	70.6	72.7
Age at pre-assessment; mean (SD)	43.9 (11.4)	48.5 (8.6)	46.6 (11.9)	48.8 (8.4)	44.7 (11.6)	46.4 (12.3)
Ethnicity						
White British & other **(ref)**	64.3	64.6	71.8	73.7	61.8	75.8
Non-White ethnicities	21.4	17.7	16.9	10.5	26.4	14.8
Not stated	14.3	17.7	1.3	5.8	11.8	9.4
Education						
Below A level **(ref)**	35.7	41.2	61.0	33.3	47.1	52.4
A level and above	35.7	41.2	21.1	33.3	20.6	28.1
First & higher degree	28.6	17.6	16.9	33.3	32.3	19.5
Employed						
Yes	42.9	58.8	67.6	52.6	60.6	58.7
No	57.1	41.2	32.4	47.4	39.4	41.3
Self-esteem						
Low <15 **(ref)**	28.6	29.4	16.9	26.3	17.7	18.8
Normal 15-25	64.3	64.7	62.0	68.4	70.6	64.8
High 25-30	7.1	5.9	21.1	5.3	11.7	16.4
Mastery; mean (SD)	12.4 (3.7)	**12.2 (3.1)**	**14.2 (3.3)****	12.6 (2.6)	12.9 (3.5)	14.1 (3.5)

** p<0.01; * p<0.05

Table 33 Covariates by relationship status (max n=182). All variables were collected at pre-assessment.

	Relationship status		
	Married$_1$ (reference)	**Single**	**Divorced/ widowed**
	n=102	**n=47**	**n=33**
	%	%	%
Gender			
Men	33.3	25.5	21.2
Women	66.7	74.5	78.8
Age at pre-assessment; mean (SD)	**47.5 (10.4)**	**38.5 (12.5)****	**53.6 (8.6)***
Ethnicity			
White British & other **(ref)**	69.6	72.3	81.8
Non-White ethnicities	17.7	17.0	15.2
Not stated	12.7	10.7	3.0
Education			
Below A level **(ref)**	54.9	39.1	45.5
A level and above	26.5	26.1	33.3
First & higher degree	18.6	34.8	21.2
Employed			
Yes	62.7	64.4	**34.4**
No	37.3	35.6	**65.6****
Self-esteem			
Low <15 **(ref)**	20.5	14.9	21.2
Normal 15-25	62.8	74.5	66.7
High 25-30	16.7	10.6	12.1
Self-esteem	19.4 (6.4)	19.0 (5.1)	19.8 (5.3)
Mastery (cont.)	13.6 (3.4)	14.0 (3.1)	13.8 (4.2)

** p<0.01; * p<0.05; **married$_1$** included civil partnership and cohabiting couples

Table 34 Covariates by number of friends and relatives seen on a monthly basis, max n=182. All variables were collected at pre-assessment.

	Number of relatives seen per month			Number of friends seen per month		
	None (ref)	**1-5**	**6+**	**None (ref)**	**1-5**	**6+**
	n=15	n=88	n=79	n=12	n=90	n=80
	%	%	%	%	%	%
Gender						
Men	33.3	29.5	27.8	16.7	25.6	35.0
Women	66.7	70.5	72.2	83.3	74.4	65.0
Age at pre-assessment; mean (SD)	51.8 (9.9)	44.9 (11.5)	46.8 (12.2)	49.2 (12.4)	46.3 (10.7)	45.8 (12.9)
Ethnicity						
White British & other **(ref)**	73.3	73.9	70.9	75.0	70.0	75.0
Non-White ethnicities	26.7	17.0	15.2	25.0	22.2	10.0
Not stated	--	9.1	13.9	--	7.8	15.0
Education						
Below A level **(ref)**	13.3	50.6	54.4	58.3	40.4	57.5
A level and above	40.0	**23.0***	**30.4***	8.3	31.5	26.2
First & higher degree	46.7	**26.4***	**15.2****	33.3	28.1	16.3
Employed						
Yes	60.0	59.3	56.4	40.0	55.1	63.8
No	40.0	40.7	43.6	60.0	44.9	36.2
Self-esteem						
Low <15 **(ref)**	26.7	25.0	11.4	50.0	22.2	11.2
Normal 15-25	66.7	61.4	72.1	41.7	64.4	**72.5****
High 25-30	6.6	13.6	16.5	8.3	13.4	16.3
Mastery (continuous)	12.1 (4.3)	13.7 (3.4)	14.2 (3.3)	11.7 (4.7)	13.9 (3.4)	13.9 (3.3)

** p<0.01; *p<0.05

7.4 Social support and percentage weight loss at each visit

Linear regression models of %WL at 4 weeks, 3 months and 6 months showed that received practical support, received negative aspects of support, provided emotional support and seeing friends on a monthly basis were associated with %WL. In models adjusting for gender, age, ethnicity, and employment, received practical support was positively associated with %WL at 4 weeks and 3 months and this was not attenuated by the adjustment for self-esteem (Table 35). Mastery was not associated with weight loss and when added to the models made no difference to the estimates. Mastery did not seem to be a mediating factor and thus was dropped from the models. Negative support was also positively associated with %WL at 3 months, though not at other visits/time points (Table 35). Providing emotional support was positively associated with %WL at 4 weeks, 3 months and 6 months (the latter attaining borderline statistical significance Table 34). Romantic relationship satisfaction appeared to be also positively associated with %WL especially at 4 weeks and 3 months post-surgery, although the statistical significance was borderline. Satisfaction with the relationship with the closest person did not seem to be associated with %WL. Seeing more friends on a monthly basis was associated with higher %WL at 3 months; those who saw 6+ friends per month had 3.12% higher weight loss at 3 months compared to seeing no friends (Table 35). There was no association between relationship status and %WL as well as seeing relatives on a monthly basis and %WL.

Linear regression models of BMI on the date of surgery, at 4 weeks, 3 months and 6 months present different results to those of %WL (Appendix IX). BMI levels varied only by romantic relationship satisfaction, satisfaction with the closest person, relationship status (with single patients having lower BMI at 3 months) and seeing friends on a monthly basis. Romantic relationship satisfaction and satisfaction with the closest person were significantly, negatively associated with BMI levels at all or most time points (Appendix IX). Seeing more friends on a monthly basis was associated with higher BMI on the day of surgery and at 4 weeks post-operation once self-esteem was added in the model adjusting for gender, age, ethnicity and employment. Losing more weight relative to own baseline weight, was therefore associated with seeing more friends on a monthly basis, regardless of higher BMI levels on the day of surgery and at 4 weeks post-operation among patients with more frequent contact with friends.

Table 35 Linear regression models of the associations between received social support, provided social support, relationship status, romantic relationship satisfaction, satisfaction with the closest person, number of friends and relatives seen on a monthly basis and %WL at 4 weeks n=152, at 3 months n=136 and at 6 months n=123. All exposures were entered in separate models.

	% WEIGHT LOSS					
	4 weeks Coefficient (SE)	**P**	**3 months Coefficient (SE)**	**p**	**6 months Coefficient (SE)**	**p**
M1: Received emotional support	0.09 (0.06)	0.14	**0.17 (0.08)**	**0.052**	0.20 (0.12)	0.11
M2: Received emotional support	0.08 (0.06)	0.22	0.14 (0.08)	0.10	0.18 (0.12)	0.13
M3: Received emotional support	0.06 (0.07)	0.33	0.14 (0.09)	0.11	0.19 (0.13)	0.14
M1: Received practical support	0.16 (0.10)	0.08	0.19 (0.14)	0.16	0.28 (0.20)	0.17
M2: Received practical support	**0.22 (0.09)**	**0.022**	**0.28 (0.14)**	**0.043**	0.32 (0.20)	0.11
M3: Received practical support	**0.22 (0.09)**	**0.023**	**0.27 (0.14)**	**0.047**	0.33 (0.20)	0.10
M1: Received negative aspects	0.14 (0.09)	0.12	**0.25 (0.12)**	**0.046**	0.14 (0.17)	0.40
M2: Received negative aspects	0.13 (0.09)	0.15	**0.28 (0.12)**	**0.026**	0.20 (0.18)	0.25
M3: Received negative aspects	0.14 (0.09)	0.12	**0.29 (0.12)**	**0.021**	0.21 (0.18)	0.24
M1: Providing emotional support	**0.13 (0.06)**	**0.031**	**0.24 (0.08)**	**0.005**	**0.23 (0.12)**	**0.056**
M2: Providing emotional support	**0.13 (0.06)**	**0.028**	**0.23 (0.08)**	**0.006**	**0.23 (0.12)**	**0.056**
M3: Providing emotional support	**0.14 (0.06)**	**0.023**	**0.24 (0.08)**	**0.005**	**0.23 (0.12)**	**0.053**
M1: Providing practical support	0.06 (0.10)	0.54	0.05 (0.14)	0.70	0.14 (0.20)	0.48
M2: Providing practical support	0.06 (0.10)	0.54	0.08 (0.14)	0.56	0.15 (0.21)	0.47
M3: Providing practical support	0.05 (0.10)	0.60	0.08 (0.14)	0.59	0.14 (0.21)	0.49
M1: Romantic relationship satisfaction						
≤A little satisfied	reference		reference		reference	
Moderately satisfied	+2.02 (1.07)	0.06	+2.58 (1.43)	0.07	+3.98 (2.29)	0.08

Very satisfied	+1.36 (0.89)	0.12	+1.90 (1.12)	0.09	+1.90 (1.90)	0.32
M2: Romantic relationship satisfaction						
≤A little satisfied **(ref)**	reference		reference		reference	
Moderately satisfied	+1.96 (1.10)	0.07	+2.53 (1.39)	0.07	+3.70 (2.30)	0.11
Very satisfied	+1.27 (0.91)	0.17	+1.91 (1.12)	0.09	+1.65 (1.93)	0.39
M3: Romantic relationship satisfaction						
≤A little satisfied **(ref)**	reference		reference		reference	
Moderately satisfied	+1.97 (1.10)	0.07	+2.51 (1.40)	0.07	+3.75 (2.31)	0.11
Very satisfied	+1.34 (0.93)	0.15	+1.88 (1.14)	0.10	+1.44 (1.96)	0.46
M1: Satisfaction with the closest person						
≤A little satisfied **(ref)**	reference		reference		reference	
Moderately satisfied	-0.18 (0.96)	0.85	-0.53 (1.34)	0.69	+0.001 (1.812)	1.0
Very satisfied	+0.36 (0.82)	0.66	-0.52 (1.12)	0.64	0.42 (1.55)	0.78
M2: Satisfaction with the closest person						
≤A little satisfied **(ref)**	reference		reference		reference	
Moderately satisfied	-0.04 (0.95)	0.96	-0.24 (1.34)	0.86	+0.15 (1.82)	0.93
Very satisfied	+0.50 (0.81)	0.53	-0.41 (1.12)	0.71	+0.46 (1.57)	0.77
M3: Satisfaction with the closest person						
≤A little satisfied **(ref)**	reference		reference		reference	
Moderately satisfied	-0.13 (0.95)	0.89	-0.33 (1.35)	0.80	+0.11 (1.83)	0.95
Very satisfied	+0.38 (0.82)	0.64	-055 (1.15)	0.63	+0.40 (1.59)	0.80
M1: Relationship status						
Married/in civil partnership/cohabiting	reference		reference		reference	
Single	-0.38 (0.65)	0.56	+0.83 (0.89)	0.35	-0.03 (1.20)	0.98
Divorced/widowed	-0.21 (0.71)	0.76	-1.13 (0.96)	0.24	-1.60 (1.45)	0.27
M2: Relationship status						
Married/in civil partnership/cohabiting	reference		reference		reference	
Single	-0.27 (0.64)	0.67	+0.88 (0.88)	0.32	+0.08 (1.20)	0.94
Divorced/widowed	0.07 (0.71)	0.91	-0.90 (0.96)	0.35	-1.83 (1.48)	0.21

M3: Relationship status						
Married/in civil partnership/cohabiting	reference		reference		reference	
Single	-0.27 (0.64)	0.67	+0.92 (0.88)	0.30	+0.09 (1.20)	0.94
Divorced/widowed	-0.03 (0.72)	0.96	-1.00 (0.97)	0.30	-1.96 (1.50)	0.19
M1: Seeing friends/month						
None (**ref**)	reference		reference		reference	
1-5	+0.71 (1.07)	0.51	**+3.23 (1.35)**	**0.018**	+1.91 (2.55)	0.45
6+	+1.36 (1.09)	0.21	**+3.78 (1.38)**	**0.007**	+2.71 (2.60)	0.29
M2: Seeing friends/month						
None (**ref**)	reference		reference		reference	
1-5	+0.31 (1.06)	0.77	**+2.83 (1.36)**	**0.039**	+1.28 (2.57)	0.59
6+	+0.77 (1.09)	0.48	**+3.16 (1.41)**	**0.026**	+1.85 (2.66)	0.48
M3: Seeing friends/month						
None (**ref**)	reference		reference		reference	
1-5	+0.23 (1.07)	0.82	**+2.81 (1.37)**	**0.042**	+1.39 (2.58)	0.59
6+	+0.66 (1.10)	0.55	**+3.12 (1.43)**	**0.031**	+1.84 (2.67)	0.49
M1: Seeing relatives/month						
None (**ref**)	reference		reference		reference	
1-5	+0.23 (1.00)	0.82	+0.25 (1.29)	0.84	-0.54 (2.02)	0.79
6+	+0.004 (1.000)	0.99	+0.28 (1.30)	0.82	-0.36 (2.03)	0.86
M2: Seeing relatives/month						
None (**ref**)	reference		reference		reference	
1-5	+0.26 (0.99)	0.79	+0.26 (1.29)	0.83	-0.51 (2.04)	0.80
6+	+0.01 (0.99)	0.99	+0.30 (1.30)	0.81	-0.55 (2.05)	0.78
M3: Seeing relatives/month						
None (**ref**)	reference		reference		reference	
1-5	+0.24 (0.99)	0.80	+0.25 (1.29)	0.84	-0.49 (2.05)	0.81
6+	-0.06 (0.99)	0.94	+0.25 (1.31)	0.84	-0.56 (2.06)	0.78

M1: age and gender, **M2**: M1 + ethnicity and employment, **M3**: M2+ self-esteem and mastery

7.5 Post-operative body mass index trajectories by social support

BMI declined over the period of post-operative follow-up in a nonlinear fashion and a quadratic function improved fit of the data. Maximum time of follow-up was approx. 8 months since surgery. In the basic model adjusting for gender and age, baseline BMI level (intercept) was 45.42 kg/m^2 and the linear BMI decrease was -2.70 kg/m^2 per month. However, the rate of decrease flattened out usually around the 4th month post-op (Figure 17). There was significant variability of BMI trajectories among patients. Figure 18 shows the variability in the initial BMI levels and the rate of BMI decline for a subsample of 50 participants.

Figure 17 BMI trajectories with 95% confidence intervals plotted separately for men and women

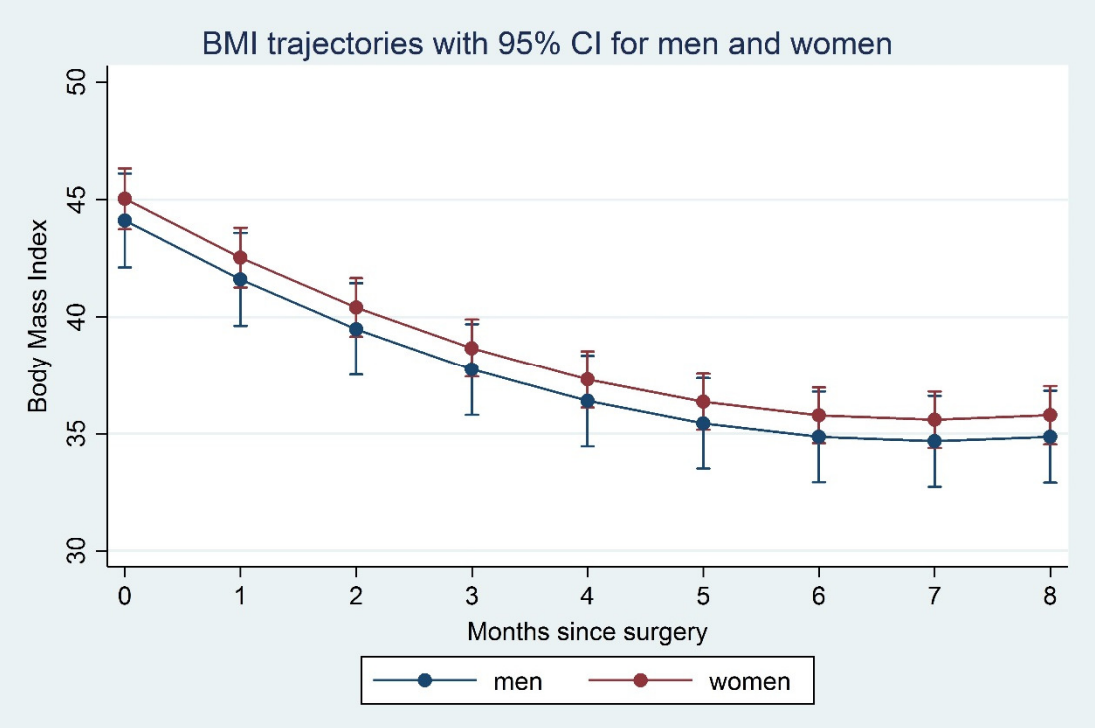
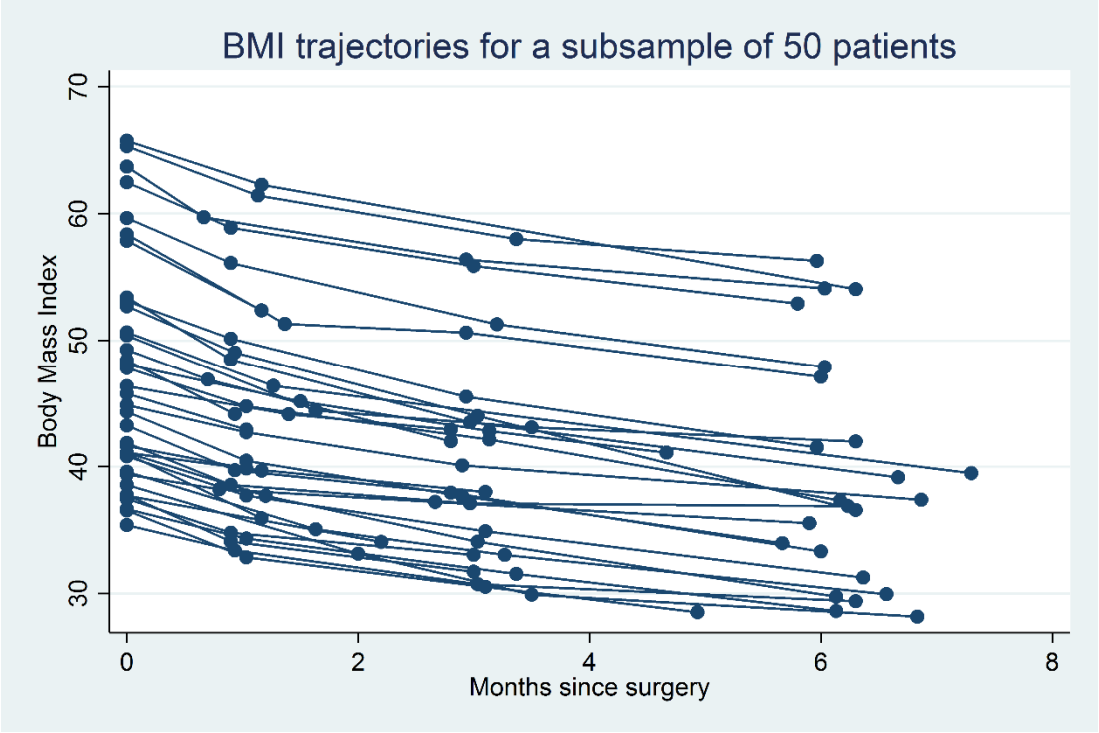


Figure 18 Variability of BMI trajectories demonstrated on a subsample of 50 patients



Baseline BMI did not differ by the level of received emotional support, however those with more emotional support had a larger negative slope estimate indicating that they had a greater reduction in BMI throughout the follow-up (-0.03, SE 0.02 kg/m^2, p=0.046, final model; Table 36). The difference in BMI decline between someone at the top vs. bottom of received emotional support distribution was -0.34, SE 0.16 kg/m^2, p=0.033 in the fully-adjusted model. This was not explained by socioeconomic or demographic characteristics or by self-esteem. Mastery did not seem to be a mediating factor and was not included in the models. There was no evidence that received emotional support (or any of the social relationship exposures) was related to non-linear change in BMI and so these estimates are not presented in the table 36. There was no evidence of the association between received practical support or negative aspects of support and BMI trajectories. Providing emotional support was not associated with baseline BMI levels and was associated with steeper BMI linear slope (-0.04, SE 0.02 kg/m^2, p=0.017, final model) before and after adjustments. The difference in BMI decline between someone at the top vs. bottom of provided emotional support distribution was -0.39, SE 0.16 kg/m^2, p=0.016 in the fully-adjusted model.

Romantic relationship satisfaction and satisfaction with the closest person were both negatively associated with baseline BMI (Table 36). Compared with being less satisfied with romantic relationship, being moderately and very satisfied with marriage or partnership was

associated with lower baseline BMI (respectively -8.30, SE 2.81 kg/m^2, p=0.003 and -7.05, SE 2.35 kg/m^2, p=0.003, final model). Compared with being less satisfied with the relationship with the closest person, being moderately and very satisfied with the closest person was also associated with lower baseline BMI (respectively -5.62, SE 2.11 kg/m^2, p=0.008 and -6.07, SE 1.81 kg/m^2, p=0.001, final model) as well as appeared to be positively associated with BMI linear slope (although the association did not attain statistical significance, p=0.07).

There was no evidence of the association between relationship status and BMI trajectories. Seeing 1-5 and 6+ friends on a monthly basis was associated with higher baseline BMI (respectively +6.16, SE 2.39 kg/m^2, p=0.010 and +5.22, SE 2.46 kg/m^2, p=0.034, final model) and steeper BMI decline (respectively -0.79, SE 0.29 kg/m^2, p=0.007 and -0.91, SE 0.30 kg/m^2 p=0.002, final model) compared to seeing no friends (Table 36). There was no evidence of the association between seeing relatives on a monthly basis and BMI trajectories.

Table 36 Trajectories of BMI by received social support, provided social support, relationship status, romantic relationship satisfaction, satisfaction with the closest person and number of friends and relatives seen on a monthly basis over follow-up from the day of surgery to 6 months post-surgery, complete case analysis, n=152. All exposures were entered in separate models.

	Intercept coefficient (SE)	**p**	**Linear slope coefficient (SE)**	**p**
M1: Received emotional support	-0.05 (0.15)	0.71	**-0.03 (0.02)**	**0.045**
M2: Received emotional support	-0.05 (0.15)	0.74	**-0.03 (0.02)**	**0.045**
M3: Received emotional support	0.07 (0.15)	0.62	**-0.03 (0.02)**	**0.046**
M1: Received practical support	-0.07 (0.22)	0.77	-0.04 (0.02)	0.14
M2: Received practical support	-0.08 (0.23)	0.71	-0.04 (0.02)	0.14
M3: Received practical support	-0.06 (0.22)	0.78	-0.04 (0.02)	0.15
M1: Received negative aspects	0.09 (0.21)	0.69	-0.04 (0.02)	0.07
M2: Received negative aspects	0.10 (0.22)	0.63	-0.04 (0.02)	0.07
M3: Received negative aspects	0.04 (0.21)	0.85	-0.04 (0.02)	0.07
M1: Providing emotional support	0.06 (0.14)	0.66	**-0.04 (0.02)**	**0.017**
M2: Providing emotional support	0.07 (0.14)	0.63	**-0.04 (0.02)**	**0.017**
M3: Providing emotional support	0.03 (0.13)	0.80	**-0.04 (0.02)**	**0.016**
M1: Providing practical support	-0.33 (0.24)	0.15	-0.001 (0.027)	0.97
M2: Providing practical support	-0.34 (0.24)	0.14	-0.001 (0.027)	0.97
M3: Providing practical support	-0.28 (0.23)	0.21	-0.001 (0.027)	0.98
M1: Romantic relationship satisfaction				
≤A little satisfied	reference		reference	
Moderately satisfied	**-8.41 (2.89)**	**0.004**	-0.005 (0.299)	0.98
Very satisfied	**-7.59 (2.38)**	**0.001**	-0.051 (0.247)	0.83
M2: Romantic relationship satisfaction				
≤A little satisfied	reference		reference	
Moderately satisfied	**-8.40 (2.91)**	**0.004**	-0.004 (0.299)	0.98
Very satisfied	**-7.69 (2.41)**	**0.001**	-0.052 (0.247)	0.83
M3: Romantic relationship satisfaction				
≤A little satisfied	reference		reference	
Moderately satisfied	**-8.30 (2.81)**	**0.003**	+0.001 (0.299)	0.99
Very satisfied	**-7.05 (2.35)**	**0.003**	-0.051 (0.247)	0.83
M1: Satisfaction with the closest person				
≤A little satisfied	reference		reference	
Moderately satisfied	**-6.05 (2.17)**	**0.005**	+0.45 (0.24)	0.06
Very satisfied	**-6.66 (1.84)**	**<0.001**	+0.36 (0.21)	0.07
M2: Satisfaction with the closest person				
≤A little satisfied	reference		reference	
Moderately satisfied	**-6.21 (2.17)**	**0.005**	+0.45 (0.24)	0.06
Very satisfied	**-6.89 (1.85)**	**<0.001**	+0.36 (0.21)	0.07
M3: Satisfaction with the closest person				
≤A little satisfied	reference		reference	
Moderately satisfied	**-5.62 (2.11)**	**0.008**	+0.45 (0.24)	0.06
Very satisfied	**-6.07 (1.81)**	**0.001**	+0.36 (0.21)	0.07

M1: Relationship status				
Married/in civil partnership/cohabiting	reference		reference	
Single	-1.76 (1.45)	0.22	-0.03 (0.15)	0.86
Divorced/widowed	-0.64 (1.64)	0.74	-0.09 (0.18)	0.62
M2: Relationship status				
Married/in civil partnership/cohabiting	reference		reference	
Single	-1.81 (1.45)	0.21	-0.03 (0.15)	0.86
Divorced/widowed	-0.62 (1.66)	0.71	+0.09 (0.18)	0.62
M3: Relationship status				
Married/in civil partnership/cohabiting	reference		reference	
Single	-1.92 (1.39)	0.16	-0.02 (0.15)	0.87
Divorced/widowed	+0.13 (0.16)	0.93	+0.08 (0.18)	0.63
M1: Seeing friends/month				
None	reference		reference	
1-5	**+5.43 (2.48)**	**0.028**	**-0.80 (0.29)**	**0.006**
6+	+4.22 (2.52)	0.094	**-0.92 (0.30)**	**0.002**
M2: Seeing friends/month				
None	reference		reference	
1-5	**+5.51 (2.50)**	**0.027**	**-0.80 (0.29)**	**0.006**
6+	+4.35 (2.56)	0.08	**-0.92 (0.30)**	**0.002**
M3: Seeing friends/month				
None	reference		reference	
1-5	**+6.16 (2.39)**	**0.010**	**-0.79 (0.29)**	**0.007**
6+	**+5.22 (2.46)**	**0.034**	**-0.91 (0.30)**	**0.002**
M1: Seeing relatives/month				
None	reference		reference	
1-5	+0.90 (2.32)	0.69	-0.12 (0.25)	0.61
6+	+0.75 (2.33)	0.74	-0.06 (0.25)	0.80
M2: Seeing relatives/month				
None	reference		reference	
1-5	+1.04 (2.34)	0.65	-0.12 (0.25)	0.61
6+	+0.90 (2.36)	0.70	-0.06 (0.25)	0.80
M3: Seeing relatives/month				
None	reference		reference	
1-5	+1.10 (2.24)	0.62	-0.12 (0.25)	0.61
6+	+1.41 (2.27)	0.53	-0.06 (0.25)	0.81

Summary

Linear regression models of %WL at 4 weeks, 3 months and 6 months showed that received practical support, received negative aspects of support, provided emotional support and seeing friends on a monthly basis were positively associated with %WL. Providing emotional support in particular emerged to be positively associated with %WL.

Received emotional support and provided emotional support were also positively associated with reduction in BMI throughout the follow-up. Romantic relationship satisfaction and satisfaction with the closest person were both negatively associated with baseline BMI. Seeing more friends on a monthly basis was associated with higher baseline BMI and steeper BMI decline. The associations between functional/structural social support measures and %WL or BMI trajectories were not explained by age, gender, ethnicity, employment status, self-esteem or mastery. As mastery was not associated with weight loss, it did not fulfil the criteria for mediation and was dropped from the models.

7.6 Discussion of the analyses of bariatric surgery patients' data

This study was the first to analyse various aspects of social support in bariatric surgery patients in the UK using validated scales and to analyse the associations between social support and both absolute and relative weight loss in the first 6 months following bariatric surgery.

7.6.1 Levels of functional and structural social support among bariatric surgery patients

Descriptive analyses suggest that bariatric surgery patients have similar or even higher levels of social support compared with the Whitehall II occupational cohort and the general population and similar marriage rates to the general population. Compared with the Whitehall II study participants, patients reported higher median received emotional support (18 vs. 15.5), slightly higher median received practical support (6 vs. 5.5) and slightly lower median received negative aspects (2 vs. 2.5). Amongst 102 patients with romantic partners, 8 patients (7.8%) reported being dissatisfied with their relationship and further 14 patients (13.7%) reported being less than satisfied with their relationship. These rates appear similar to the rates of adults in the general population in very unhappy relationships (8.4%) or a little unhappy relationships (14.2%) in 2013-2014 (ONS, 2016).

Fifty six percent of patients were married, cohabiting or in civil partnership, 25.8% of patients were single (never-married) and 18.2% of patients were divorced/widowed. These rates were different from the Whitehall II study participants: 77% married/cohabiting, 14.6% single (never-married) and 8.4% divorced/widowed, but similar to marriage rates in the general population in 2014 (51.2%; ONS, 2015). Finally, 6.6% of patients reported seeing no friends on a monthly basis and 8.2% reported seeing no relatives. Only 3 patients reported not seeing any friends and relatives on a monthly basis. Objectively, the majority of patients in this study reported some social contact on a monthly basis.

Given the relatively small sample of patients here, these findings need replication.

7.6.2 Support and surgery compliance

Patients who were declined the surgery or who decided not to proceed with the surgery reported less received emotional and practical support as well as less provided practical support to others compared with patients who proceeded to have one of the two procedures. These groups did not differ in terms of other demographic, socioeconomic or anthropometric characteristic. If replicated in a bigger study, these findings would suggest that improving levels of received social support might be beneficial for candidates who wish to qualify for bariatric surgery at the pre-surgery stage. Alternatively, these results might also indicate that patients who have poorer health and require additional tests barring them from surgery receive and provide less social support. This study is the first to report differences in social support levels between patients who do and do not proceed to bariatric surgery. Previous studies have however reported that patients who proceeded to bariatric surgery suffered from less depression and had better self-rated health compared to those who did not have the surgery (Rutledge, Adler and Friedman, 2011) as well as reported higher self-efficacy compared with patients who opted for nonsurgical obesity treatment (Kvalem et al., 2015).

This study found no difference in pre-surgery social support and compliance with post-surgery follow-up appointments. Only one previous study examined the association between marital status and follow-up compliance and found that bariatric surgery patients who stayed in the study had higher rates of marriage (68.8%) compared with those lost to follow-up (56.9%), however this difference was not statistically significant p=0.1 (Wedin et al., 2014). In qualitative studies, patients often report that social support post-surgery has helped them to adhere to post-operative medication, diet regimen, clinic follow-up appointments and support group attendance (Moore and Cooper, 2016; Ogle et al., 2016).

7.6.3 Received and provided social support and weight loss

Results from linear regression models of %WL at 4 weeks, 3 months and 6 months indicated that received emotional support, received practical support, received negative aspects of support, provided emotional support in particular were positively associated with %WL. Received emotional support and provided emotional support were also positively associated with reduction in BMI throughout the follow-up in models assessing BMI trajectories post-surgery.

The finding that received emotional support was positively associated with weight loss measured with %WL and BMI trajectory is in agreement with a previous prospective study of 131 gastric bypass patients which found that interpersonal support measured with two items "patient has told co-workers of his/her [gastric bypass] plan" and "patient has told friends of his/her [gastric bypass] plan" was positively associated with lower BMI and weight at 1 year of follow-up (Lanyon and Maxwell, 2007). All other studies, retrospective in design, did not find an association between social support and excess percentage weight loss (EWL), however found that levels of social support were higher among those with more successful weight loss (>50% EWL) and those satisfied with the surgery outcome (Livhits et al., 2010; Delin, Watts and Bassett, 1995; Vishne et al., 2004). Qualitative studies of bariatric surgery patients' support systems show that received emotional or positive social support takes many forms including empathy and understanding for patients' struggles, encouragement for making lasting lifestyle changes and focusing on the big-picture of the surgery as well as companionship during the bariatric surgery journey such as joining in with exercise and diet and accompanying the patient during the support group meetings (Liebl, Barnason and Brage Hudson, 2016; Ogle et al., 2016). Ogle et al. (2016) conclude that the underlying message of these social support provisions is that the patient "*matters*" to others and therefore close others want to "accommodate" to patients' needs and be "joint collaborators" who show interest, motivate and provide support (Ogle et al., 2016). Patients also expressed that positive support, encouragement and being able to ask for support when in need helped them to maintain weight loss over time (Liebl, Barnason and Brage Hudson, 2016).

Receiving more practical support was associated with greater %WL in the first three months since surgery. Having more practical help in the first months of the post-operative period could act as a stress buffer and help the patients to focus on their health needs as a priority (Liebl, Barnason and Brage Hudson, 2016). The surgery, a stressful experience itself, begins a process of often difficult transition as patients face challenges of new food tolerance, old cravings and adherence to new diet regimen (Liebl, Barnason and Brage Hudson, 2016; Moore and Cooper, 2016; Ogle et al., 2016; McMahon et al., 2006). Practical help during this time is usually provided by spouses/partners and involves assistance with everyday tasks such as shopping, cooking, transportation and pet care as well as reminders and prompts about post-operative diet requirements, medication and clinic follow-up appointments (Ogle et al., 2016; Moore and Cooper, 2016).

Unexpectedly received negative aspects of support were positively associated with %WL at 3 months. However, this association was explained when provided emotional support was added in the model. Provided emotional support and received negative support were positively associated r=27, p<0.001, in line with a previous study which also reported a positive correlation between negative interactions and given social support r=0.37, p<0.001 (Liang, Krause and Bennett, 2001). Patients who reported negative aspects of the relationship with the closest person such as "worries, problems and stress?" and not enough "confiding" and "practical help" could have been the main providers of emotional support to their closest person. Previous studies have found that ambivalence, both positive and negative feelings and support, are often present in relationships described as close (Spitze and Gallant, 2004; Rook et al., 2012; Fingerman, Hay and Birditt, 2004). Providing social support particularly to close relationships with complex, multiple needs can be demanding psychologically and physically (Lashewicz et al., 2012). Furthermore, relationships that both provide high social support and more negative exchanges have been found to be associated with increased emotional closeness over time (Fung et al., 2009).

Provided emotional support was consistently associated with greater %WL at all time points as well as steeper BMI decline. This finding adds to previous literature reporting various health-benefits of providing social support (Krause, Herzog and Baker, 1992; Schwartz and Sendor, 1999; Liang, Krause and Bennett, 2001; Brown et al., 2003; Piferi and Lawler, 2006; Thomas, 2010; Inagaki and Eisenberger, 2012; Poulin et al., 2013; Morelli et al., 2015; Krause, 2016; Inagaki and Eisenberger, 2016) and extends it by demonstrating that providing emotional support to others is associated with greater weight loss from bariatric surgery. Giving support to others has been associated with increased perceptions of closeness in relationships, positive affect and rewarding feelings of understanding, love and empathy (Inagaki and Eisenberger, 2012; Poulin et al., 2010; Koenig, 2007) as well as enhanced coping, wellbeing and health of the support provider (Schwartz and Sendor, 1999). There is also evidence that prosocial behaviour is associated with better physical health and better health behaviours, in particular higher physical activity (Sneed and Cohen, 2013; Oman, Thoresen and Mcmahon, 1999; Schwartz et al., 2009; Brown and Brown, 2015) as well as less smoking and lower alcohol consumption (Oman, Thoresen and Mcmahon, 1999; Wink and Dillion, 2007). It is possible that the patients who reported giving more social support experienced greater positive affect and engaged in healthier behaviours which lead to more pronounced weight loss. Findings from neuroimaging studies of support suggest that care giving, rather than care receiving, is the true stress-buffer. Providing support to others triggers brain

activity in the regions responsible for basic rewards and simultaneously dampens the activity in fear and threat regions such as amygdala (Eisenberger, 2013; Inagaki et al., 2016). The amygdala activity also plays a crucial role in regulation of food intake, emotional eating and compulsive overeating (Iemolo et al., 2013; Zhang, Li and Guo, 2011; van Bloemendaal et al., 2015). Patients who gave more emotional social support to others could experience more beneficial brain activations leading to less disturbed eating patterns.

Provided practical support was not associated with weight loss in this study. It is likely that within the first months post-operation, patients would benefit from receiving practical support themselves rather than providing practical help to others. Previous qualitative study has suggested that patients need to learn to place their health needs as a priority in order to maintain weight loss over time (Liebl, Barnason and Brage Hudson, 2016). Furthermore, as patients have occasionally remarked during questionnaire completion, not having a driving licence rendered the first of three questions on provided social support not applicable. The remaining two questions asking about help with household chores, DIY and shopping might have not captured practical help bariatric surgery candidates provide.

7.6.4 Relationship quality and weight loss

Greater romantic relationship satisfaction and satisfaction with the relationship with the closest person were both associated with significantly lower baseline BMI and lower BMI levels at all post-operative time points. They were not however associated with higher %WL or BMI decline. These findings are in agreement with a study by Lanyon and Maxwell (2007) who found no association between marital satisfaction and weight loss measured with the change in BMI and weight at 1 year since surgery. The magnitude of baseline BMI differences by relationship satisfaction was large, for example, in the final BMI trajectories models, adjusted for all covariates, patients who were moderately and very satisfied with their romantic relationship had -8.30 kg/m^2 and -7.05 kg/m^2 lower BMI at baseline compared with those a little satisfied, while patients who were moderately and very satisfied with the relationship with the closest person had -5.62 kg/m^2 and -6.07 kg/m^2 lower BMI at baseline compared with those a little satisfied. These findings are in agreement with previous studies suggesting that body weight plays an important role in relationship satisfaction (Sobal, Rauschenbach and Frongillo, 1995; Ball, Crawford and Kenardy, 2004). Many previous studies have found that relationship satisfaction improves as a result of surgery and weight loss (Hafner, Rogers and Watts, 1990; Bocchieri, Meana and Fisher, 2002b; van Hout et al.,

2006; Moore and Cooper, 2016; Bocchieri, Meana and Fisher, 2002a). There is also evidence suggesting that pre-operative well-functioning relationships improve, while less stable relationships might suffer as a results of surgery (Rand, Kuldau and Robbins, 1982; Goble, Rand and Kuldau, 1986; van Hout et al., 2006; Bocchieri, Meana and Fisher, 2002a). However, this study was unable to study change in relationship satisfaction post-surgery.

7.6.5 Structural social support and weight loss

This study did not find an association between relationship status and weight loss, in agreement with three prospective studies of gastric bypass patients which found no difference between married and unmarried in achieving 50% of excess weight loss (Coleman and Brookey, 2014), mean excess weight loss at 12 months (Ray et al., 2003) and weight loss trajectories (Baldridge et al., 2015). Current results disagree with three previous studies which found higher %EWL in non-married patients (Lutfi et al., 2006; Nelbom et al., 2010) and higher odds of successful weight loss (≥50% EWL) in married compared to non-married (Wedin et al., 2014). Two of these studies included very small sample sizes (n=89 Nelbom et al., 2010; n=80 Wedin et al., 2014) as well as gastric band patients (Lutfi et al., 2006; Wedin et al., 2014) limiting the comparison with the sample used here.

Socialising with greater number of friends was positively associated with both relative and absolute weight loss measures. Seeing more friends on a monthly basis was positively associated with %WL at 3 months as well as associated with higher baseline BMI and steeper BMI decline post-surgery. The magnitude of the association between seeing friends and %WL was large, for example in the final model adjusting for all covariates, those who reported seeing 1-5 friends and 6+ friends on a monthly basis had +2.81% and +3.12% higher %WL compared with those who reported no social contact with friends. Differences of such magnitude are clinically significant, as a previous study using a larger dataset of patients operated at the same centre as patients in this study reported an 7% increase in odds of type 2 diabetes remission with each additional %WL (OR 1.07, 95% CI: 1.03-1.12, $p<0.001$; Pucci et al. under review). These findings are in agreement with the results of a prospective study of 149 gastric bypass patients showing a positive association between number of confidants and %EWL (however the association did not reach statistical significance; Ray et al., 2003) and disagree with a retrospective study of 148 gastric bypass patients which found that

patients who achieved ≥50% EWL compared with patients who achieved <50% EWL did not vary in their reports of number of friends (Livhits et al., 2010).

Interestingly, patients who reported higher number of friends seen per month had higher baseline, pre-surgery BMI, however their BMI decreased more rapidly with time. Previous studies reported that patients' friendships and other relationships pre-surgery tend to centre around food (Geraci, Brunt and Marihart, 2014; Liebl, Barnason and Brage Hudson, 2016) and that close social ties are likely to be similar in terms of body weight (Powell et al., 2015; Sobal, 2005; Cunningham et al., 2012; Leahey et al., 2015). Surgery can reveal "who the real friends are" (Geraci, Brunt and Marihart, 2014, p.69) and lead to an end of food-centred relationships (Geraci, Brunt and Marihart, 2014; Moore and Cooper, 2016; Liebl, Barnason and Brage Hudson, 2016). Good friendships however were reported to accommodate to patients' lifestyle changes post-surgery, be understanding and flexible about patient's dietary requirements as well as change the focus of socialising from "eating out" to "doing things" (Ogle et al., 2016, p.11).

Seeing relatives on a monthly basis was not associated with weight loss in this study. In previous studies, obese individuals reported family as the most common source of negative interactions and weight stigma leading to their strategies of eating to cope (Puhl and Brownell, 2006; Carr and Friedman, 2006). It is possible that the measure of social contact with family used in this study was not sensitive enough to detect aspects of interactions with family that might be salient for bariatric surgery patients' body weight.

7.6.6 Explanatory pathways

Self-esteem and mastery did not appear to mediate the associations between social support and weight loss. Self-esteem was strongly negatively associated with BMI at all time points and seemed to be positively associated with %WL at 4 weeks and 3 months. Self-esteem was associated with received emotional support and weakly associated with seeing friends on a monthly basis. However, its inclusion in regression models did not attenuate the association between social relationship support and weight indicating that self-esteem is an independent factor associated with successful weight loss from bariatric surgery, as has been found in previous quantitative studies (Elfhag and Rössner, 2005; van Hout, Verschure and van Heck, 2005; Livhits et al., 2010; van Gemert et al., 1998).

Mastery was not associated with %WL or BMI. Higher mastery was however associated with higher romantic relationship satisfaction and higher received emotional support as well as lower negative aspects of support. Mastery might play an important role in relationship satisfaction and satisfaction with received support from the closest person. Indeed, previous studies demonstrated that self-efficacy, a closely related construct, can increase social support (Holahan and Holahan, 1987). Provided emotional support was not associated with mastery at baseline, however qualitative studies suggest that mastery, self-efficacy and personal belief in one's own ability to achieve goals, could be gained as a result of surgery and weight loss and lead to patients giving more support to others (Geraci, Brunt and Marihart, 2014; Ogle et al., 2016). Ogle et al. (2016) and Geraci et al. (2014) found that the vast majority of patients who have undergone bariatric surgery expressed a need to share their experience and provide support to bariatric surgery candidates and newly operated patients, in order to "[...] pay forward this possibility for success to like others" (Ogle et al., 2016, p.8) as well as [...] give hope and advice to the ''newbies'' (newly postops) and to keep themselves accountable during their own continued weight loss journeys" (Geraci, Brunt and Marihart, 2014, p.70).

7.6.7 Strengths and limitations

This study is the first to: report various types of social support in bariatric surgery patients in the UK as well as examine their association with weight loss using linear regression models and mixed models of BMI decline over the 6 months post-surgery. The prospective design of this study is an important strength in the bariatric literature which is dominated by retrospective studies. Pre-operative measures of social support amongst bariatric surgery patients remain under-investigated (Livhits et al., 2011; Moore and Cooper, 2016) and in many retrospective studies are often recalled by the participants a few years post-surgery (Livhits et al., 2010; Delin, Watts and Bassett, 1995; Vishne et al., 2004). Despite a small sample size in terms of statistical power, the number of patients taking part in this study is one the largest in the current literature. Furthermore, this study has had an extremely low loss to follow-up. Only 2 out of 157 patients who had the surgery did not return to any follow-up appointments and 145 patients (92%) attended at least two out of three post-operative follow-up appointments. This small loss of follow-up is unusual in bariatric research where 60% studies do not meet the recommended loss of follow-up of less than 20% (Switzer et al., 2016).

Despite relatively low loss to follow-up, patients missing their clinic appointments at 3 months (n=21) and 6 months post-op (n=34) introduce a potential bias, as patients who are experiencing successful and poor weight loss are more likely to drop out from the follow-up. Findings of this study require replication in a larger study with a social support questionnaire administered before surgery and during post-surgery follow-up. Repeated measures of social support could capture patients' support levels more accurately and enable to assess the impact of surgery and weight loss on social support and relationship satisfaction (to test a potential bi-directional association). This study therefore addressed a significant gap of bariatric literature concerning patients' pre-surgery supportive relationships, however it did not assess whether these relationships change post-surgery, as suggested by previous studies. This limitation is further discussed in Overall Discussion. Lastly, this study was not able to examine the association between supportive relationships and weight loss maintenance over long follow-up period. Bariatric surgery patients, particularly with a more severe obesity before the operation, face a significant risk of weight regain from 2 years on post-surgery, with some estimates suggesting weight regain in 50% of patients (Magro et al., 2008). As the follow-up for the present study had to be capped at 6 months post-surgery, the role of social support in weight regain and successful weight loss maintenance at later follow-up time could not be tested. It is likely that supportive, close relationships might be particularly important at the time when weight loss stabilises and the old coping mechanisms and habits might resurface.

Summary

Bariatric surgery patients in this study reported the same if not slightly higher levels of received social support as the Whitehall II study participants. Rates of marriage and relationship satisfaction were similar to those found in the general population. All but 3 patients reported social contact with friends or family on a monthly basis. Candidates who did not proceed to have the surgery reported less received emotional and practical support and lower provided practical support. There was no difference in social support characteristics between patients who did and did not comply with the post-surgery clinic appointments. Providing emotional support to others and receiving emotional support from the closest person were associated with steeper BMI decline following the surgery. Providing emotional support appeared to be consistently associated with both greater relative (mean %WL) and absolute weight loss (BMI trajectories). Similarly, socialising with a larger number of friends on a monthly basis was also associated with greater weight loss following bariatric

surgery. Romantic relationship satisfaction and satisfaction with the closest person were associated with lower baseline BMI and the magnitude of these differences was large.

Chapter 8 Overall Discussion

8.1 Main findings of analyses presented in this thesis

This thesis addressed six main objectives using data from general and clinical populations. In the general population, cross-sectional associations between functional/structural social support and BMI/WHR as well as the person-level BMI/WHR trajectories and their variation according to functional/structural social support were examined. The moderating effect of gender and the potential mediation by health behaviour and mental health covariates were also tested. In the clinical population, pre-surgery functional and structural social support of bariatric surgery patients was measured using validated social support scales. The association between functional/structural social support and relative/absolute weight loss was also examined.

The findings presented in this thesis demonstrate that functional and structural support is associated with body weight outcomes in both populations. In the general population, social support and marriage were positively associated with BMI and WHR in cross-section, however over time, emotional support, low negative aspects of support and being married compared to being single were protective against weight gain. These associations were modified by gender, for instance the association between emotional support received from the closest person and negative aspects of support was greater in magnitude for women in BMI models. Furthermore, the association between relationship status and BMI/WHR trajectories was only statistically significant in men, with the exception of divorced/widowed women having less steep WHR gain than married/cohabiting women. Health behaviours attenuated and changed associations between functional and structural social support and BMI/WHR in both cross-sectional and longitudinal models, however they have not fully explained the association. Common mental disorder was not associated with BMI and WHR trajectories.

In the clinical population, patients' levels of received social support were marginally higher than those in the Whitehall II study participants. Rates of marriage and relationship satisfaction were similar to those found in the general population. Almost all patients reported seeing at least 1 or 2 friends and relatives on a monthly basis. Providing emotional support to others and receiving emotional support from the closest person were associated with steeper BMI decline following the surgery. Providing emotional support was

consistently associated with both greater relative (mean %WL) and absolute weight loss (BMI trajectories). Seeing more friends on a monthly basis was also associated with greater relative and absolute weight loss. Greater romantic relationship satisfaction and satisfaction with the closest person were associated with lower baseline BMI. Self-esteem and mastery did not explain the associations between social support and weight loss. Some evidence was found suggesting that bariatric surgery candidates who were declined the surgery or who decided not to proceed with the surgery received less emotional and practical support as well as provided less practical support to others compared with patients who proceeded to have the surgery.

The overall message of the analyses presented in this thesis is that emotionally nurturing relationships in both populations, marriage/cohabitation in men in the general population and social contact with friends in the clinical population are related to maintaining healthy body weight over midlife as well as promoting weight loss from bariatric surgery. These associations are not explained by health behaviours, common mental disorder, self-esteem and mastery.

Close interpersonal relationships are often overlooked as factors contributing to the aetiology of obesity or weight reduction (Pachucki and Goodman, 2015; Leroux, Moore and Dubé, 2013). The current findings show that the magnitude of associations between functional/structural social support and weight gain/weight loss is moderate to sizeable. In the general population, baseline BMI levels among women varied by 0.9-1.1 kg/m^2 by practical support tertiles. Among married/cohabiting men, baseline BMI levels were lower by 0.88 kg/m^2 compared with divorced/widowed men and higher by almost a half of BMI unit compared to single men. BMI linear slopes increased by approximately 0.030 kg/m^2 more per each year of follow-up for men with lower emotional support and higher negative aspects which is comparable to the difference in BMI slopes between participants from low and high employment grades or high or low frequency of physical activity. In the clinical population, patients at the top of received and provided emotional support distributions compared with those at the bottom had greater BMI decline by 0.4 and 0.5 standard deviation respectively. Patients who were moderately and very satisfied with their romantic partnership or marriage compared with those less satisfied had lower baseline BMI levels by 1.15 and 0.98 standard deviations (-8.30 kg/m^2 and -7.05 kg/m^2 respectively). Patients who reported seeing 1-5 friends and 6+ friends on a monthly basis had +2.81% and +3.12% higher %WL compared with those who reported no social contact with friends. A previous study has

shown that a weight loss of 1% of pre-surgery body weight is clinically significant and associated with 7% higher odds of type 2 diabetes remission following the surgery (Pucci et al. under review).

8.2 Critique of the current conceptual model and alternative mechanisms behind the associations between supportive relationships and body weight outcomes

8.2.1 Critique of the current conceptual model used to guide the analyses in this thesis

The conceptual model used in this thesis was an attempt to bridge the divide between the long tradition of theoretical frameworks of social support (such as stress-buffering and main effect hypotheses) and observational studies of the association between social support and weight outcomes, which have commonly failed to clearly define social support and conceptualise potential exploratory pathways linking support to weight outcomes. In accordance with the common practice of dividing social support into functional and structural aspects, the studies presented in this thesis examined emotional, practical and negative dimensions of functional support and relationship satisfaction as well as relationship status and social contact with friends and relatives as structural social support measures. Following the Stress Buffering and Main Effect hypotheses, this thesis hypothesised that functional aspects of support may decrease psychological stress levels and buffer harmful effects of stressful life events, while structural aspects of support system may exert a continued positive contribution to individual resilience and behaviour. Drawing on previous theoretical models (such as model of hypothesised pathways linking support to health from Uchino 2006 presented in Figure 1) and empirical studies linking social support to weight outcomes, the association between social support and weight gain/weight loss was hypothesised to be explained by health behaviours, mental health, self-esteem and mastery.

The analyses presented in this thesis were the first empirical studies of the association between social support and weight outcomes guided by a clear conceptual model based on previously approved theoretical frameworks. However, previous theoretical frameworks and thus the conceptual model suffer from a few important limitations. The Stress Buffering and Main Effect models are often presented as opposing, inadvertently suggesting that a stressful situation occurs in isolation from the social support system/environment which exerts a constant positive effect on health under the main effect hypothesis. Furthermore, the

current conceptualisation of social support (stress buffering hypothesis in particular) lies mainly within the dominant "*purposive action"* framework in which social support is received or provided as means of improving the coping of a distressed person (Schlecker, 2013). As a results, the conceptualisation of social support is mainly focused on "[...] needs, provisions, give-and-take relationships, and alleviations of suffering or the inadequacies, obstacles, and failures of support" (Schlecker, 2013, p.7). Indeed, items in instruments measuring social support often assume stressful situations and difficulties, for example: "Could you rely on someone/close person in times of need", "Did you trust the closest person with most personal worries and problems" (Close Persons Questionnaire, Stansfeld and Marmot, 1992); "If I were sick, I could easily find someone to help me with my daily chores", "If I was stranded 10 miles from home, there is someone I could call who could come and get me", "If a family crisis arose, it would be difficult to find someone who could give me good advice about how to handle it" (The Social Support Questionnaire, Sarason et al., 1983); "There are several people that I trust to help solve my problems", "If I needed an emergency loan of $100, there is someone (friend, relative, or acquaintance) I could get it from" (Interpersonal Support Evaluation List, Cohen and Hoberman, 1983); "How often is each of the following kinds of support available to you if you need it?: Someone to help you if you were confined to bed, Someone you can count on to listen to you when you need to talk, Someone to give you good advice about a crisis" (MOS Social Support Survery, Sherbourne and Stewart, 1991). Thus, the current conceptualisation of social support misses a more profound rationale for and consequence of social support, namely "a mutual dependence between supporter and supported" (Schlecker, 2013, p.6) and "[…] a fundamental aspiration to perpetuate communal solidarity, sociality or human togetherness" (Schlecker, 2013, p.7). Thus, it misses the importance of affiliation and caregiving motivation behind support (See Brown and Brown. 2015). For instance, the tradition of providing food to a bereaved person, which the purposive action framework would limit to a function of stress alleviation, in fact also creates an opportunity for further contact, further support and tightening of social bonds (Hamburg, Finkenauer and Schuengel, 2014). As such, this provision ensures perpetuation of social norms and of the relationship. In fact, focusing on supportive exchanges instead of facilitation of emotional closeness, connection, empathy and compassion might contribute to failures of support interventions (Morelli et al., 2015). An alternative framework would place emotional closeness and sustaining relationship at the heart of social support as its rationale and consequence. It might also explain why emotional dimension of received and

provided support has particularly emerged as important in the findings from both general and clinical population.

To summarise, traditional theoretical models, particularly Stress Buffering hypothesis limit current understanding of social support and as a result limit our understanding of ways in which it affects health outcomes, including weight. More nuanced descriptions of mechanisms which could inform future studies of social support and weight outcomes have emerged in studies from various disciplines such as relationship science and neuroscience. These developments will be discussed in the following section.

8.2.2 Alternative mechanisms explaining the associations between supportive relationships and body weight outcomes

Alternative mechanisms of action behind emotional dimension of social support

The findings on the associations between received/provided emotional support and weight gain/weight loss confirm previous studies suggesting that emotional support and perceived relationship closeness are at the core of supportive, satisfying social relationships (Krause and Markides, 1990; Poulin et al., 2010; Morelli et al., 2015; Reis and Gable, 2015).

As previously mentioned, positive supportive exchanges on their own are often not enough to benefit health unless individuals involved in these transactions perceive their relationship as emotionally close, interdependent and caring (Morelli et al., 2015; Poulin et al., 2010; Selcuk and Ong, 2013; Slatcher and Schoebi, 2017; Brown and Brown, 2015). In turn, emotional closeness or affective-interdependence necessary for intimate relationships might facilitate greater responsiveness to each other's support needs (Slatcher and Schoebi, 2017). Indeed, greater sensitivity in support exchanges between spouses has been associated with greater satisfaction with support, more marital love and less conflict (Jensen, Rauer and Volling, 2013). Many theoretical models and empirical studies emphasise that emotionally close relationships mutually influence and regulate affect and protect against negative emotions and stress (Lakey and Orehek, 2011; Zaki and Williams, 2013; Lakey and Rhodes, 2015; Slatcher and Schoebi, 2017), for instance responsiveness in intimate relationships has been related to more beneficial stress response, namely, steeper (healthier) cortisol slopes through decreased negative affect (Slatcher, Selcuk and Ong,

2015), while social support attempts that do not invoke feelings of positive affect and self-esteem in the support recipient are viewed as unsupportive (Lakey and Rhodes, 2015).

Empathy is believed to be central to emotional support and to interpersonal emotion regulation that occurs among close social ties. Providing empathic response to a close person who is in distress is motivated by their emotional state and aims to regulate it also for the sake of support provider's own emotional state (Zaki and Williams, 2013; Hamburg, Finkenauer and Schuengel, 2014). However, food is also often used as means of "empathic emotion regulation" (Hamburg, Finkenauer and Schuengel, 2014). Sharing food and eating together facilitates bonding in a relationship (Hamburg, Finkenauer and Schuengel, 2014) and is considered an important step in moving to a cohabiting or marital relationship (Marshall and Anderson, 2002). However, when food becomes a primary form of empathic emotion regulation, it becomes a quick means of emotional soothing that does not address the cause of the emotional distress and could indicate a poor emotional closeness of relationships, lacking the skills and sensitivity to provide adequate emotional support (Hamburg, Finkenauer and Schuengel, 2014). Learning new strategies of regulating negative emotions, alternative to emotional eating, is also an important step following bariatric surgery (Bocchieri, Meana and Fisher, 2002b). Moreover, bariatric surgery often leads to ending relationships in which food is a primary source of emotional connection (Geraci, Brunt and Marihart, 2014; Moore and Cooper, 2016; Liebl, Barnason and Brage Hudson, 2016). It is possible that higher levels of emotional support in the general and clinical population were associated with maintaining healthy BMI and losing more weight from surgery through healthier eating patterns. Despite the evidence on the association between unsupportive interactions and emotional eating (Raspopow et al., 2013), no previous large-scale studies assessing the potential mediating role of emotional eating on the associations between social support and weight gain/weight loss in the general and clinical populations have been identified.

Oxytocin**,** a neuropeptide central to affiliative and prosocial behaviour, could also play a role in the association between emotionally close, supportive relationships and weight. Circulating levels of oxytocin are associated with more frequent affectionate contact (Light, Grewen and Amico, 2005) and higher self-reported social support from a partner (Grewen et al., 2005). A recent review of randomised controlled trails suggests that oxytocin boosts weight loss and metabolic function (Barengolts, 2016). Oxytocin has been associated with reduced food intake, particularly of fat and sugar and its impaired signalling has been linked

with obesity (Blevins and Baskin, 2015). Oxytocin is considered an appetite suppressant, however its anorexigenic function depends on the context and social context appears to play an important, yet currently not well understood role (Olszewski, Klockars and Levine, 2016). Oxytocin has been also associated with greater prosocial behaviour (Feldman et al., 2016; Carter, 2014; De Dreu and Kret, 2016), being generous (Kosfeld et al., 2005) and increased food sharing in chimpanzees (Wittig et al., 2014).

Providing emotional support has been found to increase affiliative feelings in a relationship and there is strong evidence to suggest that giving social support is supported by the same mechanisms as maternal caregiving (Eisenberger, 2013; Brown and Brown, 2015; Inagaki and Eisenberger, 2012, 2016). Caregiving is facilitated by numerous neurochemical processes including two important hormones, oxytocin and progesterone, both of which have been repeatedly demonstrated to be involved in stress and inflammation regulation (Brown and Brown, 2015). Therefore, Brown and Brown hypothesise that "[...] caregiving motivation itself is part of a chain of related biochemical events that function to reduce stress and inflammation and, thereby, promote health" (2015, p.3). Brown and Brown further explain that "at a neurological level, the motivational basis for parenting works in opposition to the stress response, which compels an animal to avoid, abandon, or even attack a pup" (2015, pp.6–7). Indeed, neuroimaging studies also suggest that giving support, rather than receiving it, buffers stress. Providing support to others triggers brain activity in the regions responsible for basic rewards and simultaneously dampens the activity in fear and threat regions such as amygdala (Eisenberger, 2013; Inagaki et al., 2016). The amygdala activity also plays a crucial role in regulation of food intake, emotional eating and compulsive overeating (Iemolo et al., 2013; Zhang, Li and Guo, 2011; van Bloemendaal et al., 2015). Providing emotional support to others, therefore, could be associated with less disturbed eating patterns through fewer stress activations.

> *"Future studies, for example, should attempt to determine whether health problems previously attributed to social isolation (House et al., 1988) and loneliness (Hawkley and Cacioppo, 2010) are due, in part, to lack of engagement of the caregiving system. In our view, this is a worthy venture not only because it may help resolve longstanding issues related to the health benefits of social contact – for example, whether it is better to give or to receive social support (Thomas, 2010)*

> *– but also because it may help clarify the roles of neuropeptides in regulating stress."* (Brown and Brown, 2015, p.12)

Future studies recommendations

The implication of these findings for future studies of emotional support would be to aim to capture perceptions of closeness, positive emotions, responsiveness, and empathy of the interpersonal relationship. Poor emotional closeness of relationships and lack of sensitive, adequate emotional support could be the source of emotional distress as well as lead to a tendency to rely on food for primary emotional soothing. An increased amygdala activity has been also associated with emotional eating and compulsive overeating. Evidence suggests that endocrine pathways involving oxytocin and stress could be involved in the association between supportive relationships and weight outcomes. These pathways also appear to be linked with caregiving motivation which seems to be the "true" stress buffer. Current evidence suggests that caregiving motivation might be more easily triggered when giving social support to others rather than receiving it. This might explain why self-reported giving social support, not self-reported received support was associated with more positive effects "at the level of the brain", such as higher activity in reward region and lower in the threat regions (Inagaki et al., 2016). It may also help to understand why providing emotional support emerged to be more consistently associated with weight loss in bariatric surgery patients rather than received emotional support. Currently providing emotional support emerges as the most promising aspects of support, which could be used to target stress-induced, emotional eating. Future observational studies could address whether the association between providing emotional support and weight outcomes could be explained through healthier eating practices.

Alternative mechanisms behind the association between structural aspects of social support and weight outcomes

Studies presented in this thesis find that not only functional aspects of support related to emotional support domain, but also structural measures such as marriage or cohabitation compared to being single and socialising with a greater number of friends are beneficial for weight outcomes. Previous studies and theoretical frameworks propose that regular social contact, ordinary conversations, companionship and sharing daily, routine activities play a vital role in social support and interpersonal regulation of affect and behaviour regardless of

a presence of a stressor or negative affect (Lakey and Orehek, 2011). Relationship status and number of friends seen per month used here are good proxy measures of regular social contact and companionship. Meeting with a higher number of friends could also indicate a greater diversity of social ties and thus higher chances of effective interpersonal regulation (Lakey and Orehek, 2011). Daily contact with a close person, such as spouse or close friend, has been demonstrated to act as a "zeitgeber", an external factor that entrains and stabilises biological rhythm, for instance HPA axis function and diurnal cortisol patterns (Stetler and Miller, 2008). Indeed, an analysis using the Whitehall II data has shown that married participants have steeper cortisol decline across the day (Tymoszuk et al. manuscript in preparation). Sharing meals can also act as a zeitgeber and is a routine part of daily marital or cohabiting life as well as a frequent activity among friends and close others.

Eating together with close social ties has however also been associated with increased food intake and portion size, particularly of high energy food (de Castro and Brewer, 1992; Redd and de Castro, 1992; de Castro, 1994; Salvy et al., 2007). The study of bariatric surgery patients presented in this thesis demonstrated that socialising with a greater number of friends is linked with higher weight before the surgery confirming previous reports that patients' close relationships pre-surgery tend to centre around food (Geraci, Brunt and Marihart, 2014; Liebl, Barnason and Brage Hudson, 2016) and that friends can influence body weight (Cunningham et al., 2012).

Future studies recommendations

Future studies could assess whether people who objectively spend more time in presence of close relationships differ in terms of regularity of meals and other daily routines such as sleep. The current analyses have not examined the role of sleep in these associations. However, sleep quality and duration have been previously associated with both social support and obesity (Nordin, Knutsson and Sundbom, 2008; Kim, Chun and Kwon, 2011; Patel and Hu, 2008; Cappuccio et al., 2008; Lauderdale et al., 2009; Stafford et al., 2017). Future studies could also examine whether being accompanied by close relationships is associated with the amount of calories consumed, but also calories expanded, which to the best of my knowledge, has not been addressed in previous studies.

8.3 Limitations of current studies

8.3.1 Unknown directionality of the association

> *"[…] Connecting body weight to relationships is not a simple empirical task. […] In short, understanding how key features of intimate relationships – how and why they form, what makes them successful, rewarding, and enduring, and why they often fail – influence body weight is very challenging because each of those features is potentially affected, directly and indirectly, by people's body characteristics."* (Wilson, 2012, pp.431–432)

The main limitation of the analyses presented in this thesis as well as other studies examining the association between social support and body weight is the possibility of a bi-directional association. Analyses of the general and clinical populations assess social support aspects measured at only one point in time, which limits capturing individuals' support levels accurately and does not allow for testing a potential bi-directional association. It remains unknown if body weight status factors in social support exchanges, for instance there is no evidence on whether people are less, more or equally likely to provide social support to an obese person compared with an underweight or normal weight person. There is some evidence suggesting that obese individuals might receive less emotional support and suffer more conflict in their relationships with family. A study of 3,656 participants of MIDUS study reported that participants who were overweight or obese in young adulthood reported a decrease in emotional support from family as their BMI increased (Carr and Friedman, 2006). Obese individuals also reported more negative interactions with family members and less emotional support compared with normal weight counterparts (Carr and Friedman, 2006). Carr and Friedman suggest that obesity may hinder high quality family relationships due to "[…] intrusiveness of obesity on daily practices and routines" (2006, p.142).

Previous studies have also reported changes in bariatric surgery patients' social relationships post-surgery. In a qualitative study, patients following a gastric bypass reported receiving more positive and respectful reactions from others, which in some cases evoked resentful and angry feelings at people who positively changed their treatment of the patient following the surgery (Bocchieri, Meana and Fisher, 2002b). These changes often provoked the patients to question "[…] would this person have treated me this well when I was obese?

(Bocchieri, Meana and Fisher, 2002b, p.786). Many previous studies report that bariatric surgery affects marital relationships positively leading to greater satisfaction, improvements in sexual intimacy and emotional connection (Moore and Cooper, 2016; van Hout et al., 2006; Bocchieri, Meana and Fisher, 2002a; Romo and Dailey, 2014; Bocchieri, Meana and Fisher, 2002b). In a recent qualitative study, the majority of patients reported enhanced emotional bond with their partners following the surgery including improvements in verbal and nonverbal communication including less conflict and more physical affection (Moore and Cooper, 2016, p.501). Some studies have also found negative changes in the relationship dynamic including jealousy, more conflict, declines in intimacy and greater rates of divorce (Bocchieri, Meana and Fisher, 2002a; Moore and Cooper, 2016; Liebl, Barnason and Brage Hudson, 2016; van Hout et al., 2006; Romo and Dailey, 2014; Bocchieri, Meana and Fisher, 2002b). Some bariatric surgery patients reported that their partners felt insecure and threatened by their weight loss fearing that the patients would end the relationship and look for more compatible partners (Moore and Cooper, 2016). Partners' insecurity had implications for communication and support in these relationships, leading to more conflict and less support (Moore and Cooper, 2016). Finally, there is also some evidence to suggest that good quality relationships might improve post-surgery, while poor quality relationships might worsen post-surgery (Rand, Kuldau and Robbins, 1982; Goble, Rand and Kuldau, 1986; van Hout et al., 2006; Bocchieri, Meana and Fisher, 2002a).

Patients' social functioning, social interactions and social participation have been found to change beneficially post-surgery as well (Liebl, Barnason and Brage Hudson, 2016; Bocchieri, Meana and Fisher, 2002a; van Hout et al., 2006; van Gemert et al., 1998). Patients in previous studies reported enhanced mood and energy levels, which in turn increased their ability and willingness to engage in social activities (Bocchieri, Meana and Fisher, 2002b; Liebl, Barnason and Brage Hudson, 2016; Geraci, Brunt and Marihart, 2014; van Hout et al., 2006; Bocchieri, Meana and Fisher, 2002a). Post-surgery, patients have also scored higher on social competence and assertiveness measured with the Scale for Interpersonal Behavior (Arrindell and van der Ende, 1985; Arrindell et al., 2001) which assesses frequency of expression of positive and negative feelings about interpersonal behaviour of others as well as self-expression (van Gemert et al., 1998). Patient's enhanced confidence and social competence together with simultaneous decreases in social stigma and discrimination may lead to changes in patients' support networks and quality of social interactions (Bocchieri, Meana and Fisher, 2002b; Dierk et al., 2006; Bocchieri, Meana and Fisher, 2002a). Furthermore, bariatric surgery is also associated with improved employment opportunities, which could

lead to a gain in social network (Bocchieri, Meana and Fisher, 2002a; van Hout et al., 2006; Geraci, Brunt and Marihart, 2014).

Future studies recommendations

Future observational studies should aim to test the directionality of the association between social support and weight outcomes using repeated data on weight and social support and statistical techniques to assess how changes in support and weight are related to each other over time. Future studies with repeated social support measures could examine if emotional support increases and negative interactions decrease following the surgery and if these changes are moderated by baseline relationship satisfaction. Studies could also examine whether frequency and satisfaction with social contact increase following the surgery and whether these changes have implications for functional social support.

8.3.2 Critique of the instrument used to measure received social support and of considering various aspects of social relationships individually

The Close Persons Questionnaire assessing social support received from the closest person was used to analyse social support in both general and clinical populations. This instrument suffers from few limitations. It might be less accurate at capturing women's received social support, as women have been consistently shown to have more sources of social support/multiple close persons (Antonucci and Akiyama, 1987; Fuhrer et al., 1999; Fuhrer and Stansfeld, 2002). Moreover, it is unclear what criteria guide people's choice for nominating a given individual as the closest person. Previous qualitative study has shown that social support received from one source such as spouse or close friend could be perceived as more empathetic and positive than social support from other sources, often family members (Ogle et al., 2016). Although the closest person, usually a partner or spouse, tends to be the main provider of support in both general and clinical populations, support systems are diverse and dynamic, particularly among patients going through a life-changing surgery. Patients can find new sources of support post-surgery (for instance supportive co-workers) and end old, food-centred ones (Geraci, Brunt and Marihart, 2014; Liebl, Barnason and Brage Hudson, 2016). Recent qualitative study by Ogle et al. (2016) has shown that patients receive various types of support from different support sources: health professionals, other patients ("like others") and close ties such as partners, family members and friends. Ogle et al. (2016) elegantly conclude that "[...] participants experienced

supportive actions as intersecting and amalgamated, highlighting the notion it "takes a village" of varied individuals to garner the support needed to successfully navigate the path of bariatric surgery" (p. 13). Fuhrer and Stansfeld (2002) concluded that support from four closest people captured social support more accurately compared with support from the single closest person and may represent a more gender-fair measure of social support. Including social support from four closest persons strengthened the associations with self-reported physical health and psychological morbidity, however the size of the magnitude was modest to moderate (Fuhrer and Stansfeld, 2002).

> *"The nondifferentiation of social support highlights the atheoretical treatment of social support as an agent of change in reducing obesity."* (Leroux, Moore and Dubé, 2013, p.7)

Another limitation of this and previous studies further concerns the conceptualisation and measurement of social support. A large variation in the definitions of social support in both general populations and bariatric surgery literature limits the comparability of present findings with previous studies. Analysis of the general population found that low emotional support was associated with weight gain over time similarly to Oliveira et al. (2013). However, here emotional support was measured with seven items evaluating an emotional bond with the closest person based on trust, confiding and sharing hobbies and interests, while emotional support in Oliveira et al. (2013) was measured with a single item "Sometimes we need other people's help and support. Do you have a family member or friend who helps out if you need to talk to someone about personal problems?" and the answers were dichotomised as "yes" and "no" (Oliveira et al., 2013). Other studies of social support and body weight in general population have defined social support as social experiences with others (van Oostrom et al., 1995; Croezen et al., 2012), strain in relationships (Block et al., 2009) or measured it with the Social Network Index (Kaye et al., 1993). Similarly in bariatric and nonsurgical weight loss literature, social support has also been inconsistently defined and in some cases lacking definition (Vishne et al., 2004) (Verheijden et al., 2005; Leroux, Moore and Dubé, 2013; Lanyon and Maxwell, 2007). Present findings on emotional support and its association with greater weight loss were compared with another study which measured social support with an item "patient has told coworkers/friends of his/her [gastric bypass] plan" (Lanyon and Maxwell, 2007).

The analyses presented in this thesis have followed a long tradition of separating social relationship into functional and structural aspects and have focused on social support as a

social relationship-related exposure of choice. A lack of overarching framework explaining the interplay of various conceptualisations and measures of social relationships has led to them being examined in isolation in these and previous studies. As a result previous studies examining the association between weight outcomes and: social networks (Christakis and Fowler, 2007; See Moore, 2010; Pachucki and Goodman, 2015; Powell et al., 2015 for reviews) social capital (Holtgrave and Crosby, 2006; Moore et al., 2009; Moore, 2010; Powell et al., 2015) social trust and participation (Ali and Lindström, 2006; Poortinga, 2006; Moore, 2010) and social support (Wing et al., 1991; Räikkönen, Matthews and Kuller, 1999; Ali and Lindström, 2006; Croezen et al., 2012; Kershaw et al., 2014; Powell et al., 2015) and loneliness (Whisman, 2010; Lauder et al., 2006; Luo et al., 2012; Hawkley and Cacioppo, 2003; Shankar et al., 2011) all form separate literatures. Thus due to a lack of previous evidence on the interplay between the social relationship measures to guide the analyses, the functional and structural aspects of social support were not mutually adjusted for in the models. Examination of additional aspects of social relationships such as social networks, social participation or loneliness which may also be associated with weight outcomes was considered beyond the scope of the current thesis though it is acknowledged that these may confound the association between social support and weight gain/loss seen here.

Future studies recommendations

Using a social support instrument to measure received social support from multiple sources could capture levels of received social support more accurately and help to inform about patients support system before and after the surgery. Although a consensus on the standardisation of social support instruments might not ever be achieved, a review of current measures and a critical discussion of aspects of social relationships believed to be central to supportive relationships (such as meaningful, responsive and emotionally-nurturing interactions) is another essential next step. The lack of an overarching framework explaining the interplay of various measures of social relationships should be also addressed next. However, these considerably challenging endeavours will require a collective action of many social relationships experts.

8.3.3 Generalisability

Body weight and composition trajectories have been dramatically shaped by changes in the environment over the last century, the so-called “obesogenic” environment (Komlos and

Brabec, 2011; Ogden et al., 2004). It is now a well-established fact that prevalence of overweight and obesity and rate of weight gain have been increasing for younger generations (older birth cohorts) compared with older generations (earlier birth cohorts) (Jacobsen et al., 2001; He and Baker, 2004; Barone et al., 2006; Clarke et al., 2009; Nooyens et al., 2009; Dugravot et al., 2010; Walsemann and Ailshire, 2011; Caman et al., 2013; Hulmán et al., 2014; Johnson et al., 2015; Stenholm et al., 2015). Important cultural changes affecting interpersonal relationships have also occurred over the past few decades such as declining marriage rates, increased age at first marriage and changes to marriage's function and relationship stability (Williams and Umberson, 2004; Liu and Umberson, 2008). Social norms within couples, families and social networks affecting preferences for meals eaten outside home or ready-made meals may differ by generation. It remains unknown if the association between social support and body weight varies by year of birth. As the temporal changes in practices and levels of received and provided social support are also unknown, it is difficult to speculate if and how the association might have changed over time.

8.4 Conclusions

The study using the Whitehall II data extends previous studies by demonstrating that BMI and WHR trajectories are associated with social support in both men and women during mid-life independently of health behaviours, mental health and socioeconomic status. The Whitehall II study is an occupational cohort, yet if replicated in other general population cohorts, these results could inform designing intervention studies aiming to facilitate maintaining healthy BMI and WHR levels by improving support networks of middle-aged people.

The analyses using the clinical population were the first to investigate pre-surgery levels of social support among bariatric surgery patients in the UK and their association with weight loss from surgery. The social relationships measures used in the study of bariatric surgery patients have the potential to be translational and contribute to psychosocial examination of bariatric surgery candidates. The differences in %WL between patients with low and high levels of providing emotional support and low and high social contact with friends were in a range of 1%-3%, which represent a clinically significant difference. This study has also found substantial differences in baseline BMI by relationship satisfaction. If these findings are replicated in a larger study, they would suggest that patients should be encouraged to seek prosocial activities and more contact with friends. This study further highlights the need to

consider the social environment to understand more about the prognosis for bariatric surgery patients.

The findings of this thesis suggest that emotional dimension of support in both populations, being married in men in the general population and greater contact with friends in clinical population are related to maintaining healthy body weight over midlife as well as promoting weight loss from bariatric surgery. Contrary to previous hypotheses, health behaviours, common mental disorder, self-esteem and mastery did not explain these associations. These findings are in early stages and warrant replication: a) in more representative samples, particularly in a non-occupational, nationally representative cohort, b) with a bigger sample size, particularly in the clinical sample, c) in studies using repeated social support measures capturing in particular emotional and caring aspects of support. If supported, these findings could inform intervention studies and clinical practice. More research is needed on the emotional dimension of social support, particularly provided emotional support to others. Future studies should aim to use repeated measures of social support and test directionality of the association between social support and weight outcomes, particularly in the clinical population. Future studies would benefit from improved conceptual models and an overarching framework explaining the interplay of various measures of social relationships.

References

Abilés, V., Rodríguez-Ruiz, S., Abilés, J., Mellado, C., García, A., Pérez de la Cruz, A. and Fernández-Santaella, M.C., 2010. Psychological characteristics of morbidly obese candidates for bariatric surgery. *Obesity Surgery*, 20(2), pp.161–7.

Abu-Jaish, W. and Rosenthal, R.J., 2010. Sleeve gastrectomy: a new surgical approach for morbid obesity. *Expert Review of Gastroenterology & Hepatology*, 4(1), pp.101–119.

Ali, S.M. and Lindström, M., 2006. Socioeconomic, psychosocial, behavioural, and psychological determinants of BMI among young women: differing patterns for underweight and overweight/obesity. *European Journal of Public Health*, 16(3), pp.325–331.

Allender, S. and Rayner, M., 2007. The burden of overweight and obesity-related ill health in the UK. *Obesity Reviews*, 8(5), pp.467–73.

Allgöwer, A., Wardle, J. and Steptoe, A., 2001. Depressive symptoms, social support, and personal health behaviors in young men and women. *Health Psychology,* 20(3), pp.223–7.

Angrisani, L., Santonicola, A., Iovino, P., Formisano, G., Buchwald, H. and Scopinaro, N., 2015. Bariatric Surgery Worldwide 2013. *Obesity Surgery*, 25(10), pp.1822–32.

Antonucci, T.C. and Akiyama, H., 1987. An examination of sex differences in social support among older men and women. *Sex Roles*, 17(11–12), pp.737–749.

Arnold, M., Pandeya, N., Byrnes, G., Renehan, A.G., Stevens, G.A., Ezzati, M., Ferlay, J., Miranda, J.J., Romieu, I., Dikshit, R., Forman, D. and Soerjomataram, I., 2014. Global burden of cancer attributable to high body-mass index in 2012: a population-based study. *The Lancet Oncology*, 16(1), pp.36–46.

Arrindell, W.A., Bridges, K.R., van der Ende, J., St Lawrence, J.S., Gray-Shellberg, L., Harnish, R., Rogers, R. and Sanderman, R., 2001. Normative studies with the Scale for Interpersonal Behaviour (SIB): II. US students. A cross-cultural comparison with Dutch data. *Behaviour Research and Therapy*, 39(12), pp.1461–79.

Arrindell, W.A. and van der Ende, J., 1985. Cross-sample invariance of the structure of self-reported distress and difficulty in assertiveness: Experiences with the scale for interpersonal behaviour. *Advances in Behaviour Research and Therapy*, 7(4), pp.205–243.

Averett, S.L., Sikora, A. and Argys, L.M., 2008. For better or worse: relationship status and body mass index. *Economics and Human Biology*, 6(3), pp.330–349.

Azur, M.J., Stuart, E.A., Frangakis, C. and Leaf, P.J., 2011. Multiple imputation by chained equations: what is it and how does it work? *International Journal of Methods in Psychiatric Research*, 20(1), pp.40–49.

Baldridge, A.S., Pacheco, J.A., Aufox, S.A., Kim, K.-Y.A., Silverstein, J.C., Denham, W., Hungness, E., et al., 2015. Factors Associated With Long-Term Weight Loss Following Bariatric

Surgery Using 2 Methods for Repeated Measures Analysis. *American Journal of Epidemiology*, 182(3), pp.235–43.

Ball, K., Crawford, D. and Kenardy, J., 2004. Longitudinal relationships among overweight, life satisfaction, and aspirations in young women. *Obesity Research*, 12(6), pp.1019–30.

Baltrus, P.T., Lynch, J.W., Everson-Rose, S., Raghunathan, T.E. and Kaplan, G.A., 2005. Race/ethnicity, life-course socioeconomic position, and body weight trajectories over 34 years: the Alameda County Study. *American Journal of Public Health*, 95(9), pp.1595–601.

Bamia, C., Halkjaer, J., Lagiou, P., Trichopoulos, D., Tjønneland, A., Berentzen, T.L., Overvad, K., et al., 2010. Weight change in later life and risk of death amongst the elderly: the European Prospective Investigation into Cancer and Nutrition-Elderly Network on Ageing and Health study. *Journal of Internal Medicine*, 268(2), pp.133–44.

Barengolts, E., 2016. Oxytocin - an emerging treatment for obesity and dysglycemia: Review of randomized controlled trials and cohort studies. *Endocrine Practice*, 22(7), pp.885–894.

Barger, S.D. and Cribbet, M.R., 2016. Social support sources matter: Increased cellular aging among adults with unsupportive spouses. *Biological Psychology,* 115, pp.43–49.

Barhouch, A.S., Padoin, A. V, Casagrande, D.S., Chatkin, R., Süssenbach, S.P., Pufal, M.A., Rossoni, C. and Mottin, C.C., 2016. Predictors of Excess Weight Loss in Obese Patients After Gastric Bypass: a 60-Month Follow-up. *Obesity Surgery,* 26(6), pp.1178–85.

Barone, B.B., Clark, J.M., Wang, N.-Y., Meoni, L.A., Klag, M.J. and Brancati, F.L., 2006. Lifetime weight patterns in male physicians: the effects of cohort and selective survival. *Obesity*, 14(5), pp.902–8.

Barrera, M., 1986. Distinctions between social support concepts, measures, and models. *American Journal of Community Psychology*, 14(4), pp.413–445.

Bayham, B.E., Bellanger, D.E., Hargroder, A.G., Johnson, W.D. and Greenway, F.L., 2012. Racial differences in weight loss, payment method, and complications following Roux-en-Y gastric bypass and sleeve gastrectomy. *Advances in Therapy*, 29(11), pp.970–8.

Beck, N.N., Johannsen, M., Støving, R.K., Mehlsen, M. and Zachariae, R., 2012. Do postoperative psychotherapeutic interventions and support groups influence weight loss following bariatric surgery? A systematic review and meta-analysis of randomized and nonrandomized trials. *Obesity Surgery*, 22(11), pp.1790–7.

Benoit, S.C., Hunter, T.D., Francis, D.M. and De La Cruz-Munoz, N., 2014. Use of bariatric outcomes longitudinal database (BOLD) to study variability in patient success after bariatric surgery. *Obesity Surgery*, 24(6), pp.936–43.

Berkman, L.F., Glass, T., Brissette, I. and Seeman, T.E., 2000. From social integration to health: Durkheim in the new millennium. *Social Science & Medicine*, 51(6), pp.843–857.

Berkman, L.F., Leo-Summers, L. and Horwitz, R.I., 1992. Emotional support and survival after myocardial infarction. A prospective, population-based study of the elderly. *Annals of Internal Medicine*, 117(12), pp.1003–9.

Berkman, L.F. and Syme, S.L., 1979. Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology*, 109(2), pp.186–204.

Bigaard, J., Tjønneland, A., Thomsen, B.L., Overvad, K., Heitmann, B.L. and Sørensen, T.I.A., 2003. Waist circumference, BMI, smoking, and mortality in middle-aged men and women. *Obesity Research,* 11(7), pp.895–903.

Birditt, K.S., Jackey, L.M.H. and Antonucci, T.C., 2009. Longitudinal patterns of negative relationship quality across adulthood. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 64(1), pp.55–64.

Björntorp, P., 2001. Do stress reactions cause abdominal obesity and comorbidities? *Obesity Reviews*, 2(2), pp.73–86.

Blevins, J.E. and Baskin, D.G., 2015. Translational and therapeutic potential of oxytocin as an anti-obesity strategy: Insights from rodents, nonhuman primates and humans. *Physiology & Behavior*, 152, pp.438–449.

Block, J.P., He, Y., Zaslavsky, A.M., Ding, L. and Ayanian, J.Z., 2009. Psychosocial stress and change in weight among US adults. *American Journal of Epidemiology*, 170(2), pp.181–192.

van Bloemendaal, L., Veltman, D.J., ten Kulve, J.S., Drent, M.L., Barkhof, F., Diamant, M. and IJzerman, R.G., 2015. Emotional eating is associated with increased brain responses to food-cues and reduced sensitivity to GLP-1 receptor activation. *Obesity*, 23(10), pp.2075–2082.

Bocchieri, L.E., Meana, M. and Fisher, B.L., 2002a. A review of psychosocial outcomes of surgery for morbid obesity. *Journal of Psychosomatic Research*, 52(3), pp.155–65.

Bocchieri, L.E., Meana, M. and Fisher, B.L., 2002b. Perceived psychosocial outcomes of gastric bypass surgery: a qualitative study. *Obesity Surgery*, 12(6), pp.781–8.

Botoseneanu, A. and Liang, J., 2011. Social stratification of body weight trajectory in middle-age and older Americans: results from a 14-year longitudinal study. *Journal of Aging and Health*, 23(3), pp.454–80.

Botoseneanu, A. and Liang, J., 2012. The effect of stability and change in health behaviors on trajectories of body mass index in older Americans: a 14-year longitudinal study. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, 67(10), pp.1075–84.

Botoseneanu, A. and Liang, J., 2013. Latent heterogeneity in long-term trajectories of body mass index in older adults. *Journal of Aging and Health*, 25(2), pp.342–63.

Brandão, I., Ramalho, S., Pinto-Bastos, A., Arrojado, F., Faria, G., Calhau, C., Coelho, R. and Conceição, E., 2015. Metabolic profile and psychological variables after bariatric surgery: association with weight outcomes. *Eating and Weight Disorders*, 20(4), pp.513–8.

Breines, J.G. and Chen, S., 2013. Activating the inner caregiver: The role of support-giving schemas in increasing state self-compassion. *Journal of Experimental Social Psychology*, 49(1), pp.58–64.

Brown, R.M. and Brown, S.L., 2014. Informal Caregiving: A Reappraisal of Effects on Caregivers. *Social Issues and Policy Review*, 8(1), pp.74–102.

Brown, S.L. and Brown, R.M., 2015. Connecting prosocial behavior to improved physical health: Contributions from the neurobiology of parenting. *Neuroscience & Biobehavioral Reviews*, 55, pp.1–17.

Brown, S.L., Nesse, R.M., Vinokur, A.D. and Smith, D.M., 2003. Providing Social Support May Be More Beneficial Than Receiving It: Results From a Prospective Study of Mortality. *Psychological Science*, 14(4), pp.320–327.

Buchwald, H., Avidor, Y., Braunwald, E., Jensen, M.D., Pories, W., Fahrbach, K. and Schoelles, K., 2004. Bariatric surgery: a systematic review and meta-analysis. *JAMA*, 292(14), pp.1724–37.

Buchwald, H., Estok, R., Fahrbach, K., Banel, D., Jensen, M.D., Pories, W.J., Bantle, J.P. and Sledge, I., 2009. Weight and type 2 diabetes after bariatric surgery: systematic review and meta-analysis. *The American Journal of Medicine*, 122(3), p.248–256.

Buchwald, H. and Oien, D.M., 2013. Metabolic/bariatric surgery worldwide 2011. *Obesity Surgery*, 23(4), pp.427–36.

Caman, O.K., Calling, S., Midlöv, P., Sundquist, J., Sundquist, K. and Johansson, S.E., 2013. Longitudinal age-and cohort trends in body mass index in Sweden--a 24-year follow-up study. *BMC Public Health*, 13, p.893.

Canetti, L., Berry, E.M. and Elizur, Y., 2009. Psychosocial predictors of weight loss and psychological adjustment following bariatric surgery and a weight-loss program: the mediating role of emotional eating. *The International Journal of Eating Disorders*, 42(2), pp.109–17.

Cappuccio, F.P., Taggart, F.M., Kandala, N.-B., Currie, A., Peile, E., Stranges, S. and Miller, M.A., 2008. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep*, 31(5), pp.619–26.

Carr, D. and Friedman, M.A., 2006. Body Weight and the Quality of Interpersonal Relationships. *Social Psychology Quarterly,* 69(2), pp.127–149.

Carter, C.S., 2014. Oxytocin Pathways and the Evolution of Human Behavior. *Annual Review of Psychology*, 65(1), pp.17–39.

de Castro, J.M., 1994. Family and friends produce greater social facilitation of food intake than other companions. *Physiology & Behavior*, 56(3), pp.445–455.

de Castro, J.M. and Brewer, E.M., 1992. The amount eaten in meals by humans is a power function of the number of people present. *Physiology & Behavior*, 51(1), pp.121–5.

Chandarana, K. and Batterham, R.L., 2012. Shedding pounds after going under the knife: metabolic insights from cutting the gut. *Nature Medicine*, 18(5), pp.668–9.

Cherlin, A.J., 2004. The deinstitutionalization of American marriage. *Journal of Marriage and Family*, 66(4), pp.848–861.

Chor, D., Faerstein, E., Kaplan, G.A., Lynch, J.W. and Lopes, C.S., 2004. Association of weight change with ethnicity and life course socioeconomic position among Brazilian civil servants. *International Journal of Epidemiology*, 33(1), pp.100–6.

Chou, C., Bentler, P.M. and Pentz, M.A., 1998. Comparisons of two statistical approaches to study growth curves: The multilevel model and the latent curve analysis. *Structural Equation Modeling: A Multidisciplinary Journal*, 5(3), pp.247–266.

Christakis, N.A. and Fowler, J.H., 2007. The spread of obesity in a large social network over 32 years. *The New England Journal of Medicine*, 357(4), pp.370–379.

Christou, N. V, Sampalis, J.S., Liberman, M., Look, D., Auger, S., McLean, A.P.H. and MacLean, L.D., 2004. Surgery decreases long-term mortality, morbidity, and health care use in morbidly obese patients. *Annals of Surgery*, 240(3), pp.416-23–4.

Clark, M.S., Aragon, O.R. and Hirsch, J.L., 2015. Social relationships in adulthood. In: J., Wright, ed., *International Encyclopedia of Social and Behavioral Sciences*, 2nd ed. Oxford: Elsevier.

Clarke, P., O'Malley, P.M., Johnston, L.D. and Schulenberg, J.E., 2009. Social disparities in BMI trajectories across adulthood by gender, race/ethnicity and lifetime socio-economic position: 1986-2004. *International Journal of Epidemiology*, 38(2), pp.499–509.

Cohen, S., 2004. Social Relationships and Health. *The American Psychologist*, 59(8), pp.676–84.

Cohen, S. and Hoberman, H.M., 1983. Positive Events and Social Supports as Buffers of Life Change Stress. *Journal of Applied Social Psychology*, 13(2), pp.99–125.

Cohen, S., Underwood, G.L. and Gottlieb, H.B., 2000. Social Support Measurement and Intervention: A Guide for Health and Social Scientists. 1st ed. New York, NY: Oxford University Press.

Cohen, S. and Wills, T.A., 1985. Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, 98(2), pp.310–57.

Coleman, K.J. and Brookey, J., 2014. Gender and racial/ethnic background predict weight loss after Roux-en-Y gastric bypass independent of health and lifestyle behaviors. *Obesity Surgery*, 24(10), pp.1729–36.

Colquitt, J.L., Pickett, K., Loveman, E. and Frampton, G.K., 2014. Surgery for weight loss in adults. The Cochrane Database of Systematic Reviews, (8), p.CD003641.

Courcoulas, A.P., Christian, N.J., O'Rourke, R.W., Dakin, G., Patchen D.E., Flum, D.R., et al., 2015. Preoperative factors and 3-year weight change in the Longitudinal Assessment of Bariatric Surgery (LABS) consortium. *Surgery for Obesity and Related Diseases*, 11(5), pp.1109–18.

Craddock, E., vanDellen, M.R., Novak, S.A. and Ranby, K.W., 2015. Influence in Relationships: A Meta-Analysis on Health-Related Social Control. *Basic and Applied Social Psychology*, 37(2), pp.118–130.

Croezen, S., Picavet, H.S.J., Haveman-Nies, A., Verschuren, W.M.M., de Groot, L.C.P.G.M. and van't Veer, P., 2012. Do positive or negative experiences of social support relate to current and future health? Results from the Doetinchem Cohort Study. *BMC Public Health,* 12, p.65.

Cunningham, S.A., Vaquera, E., Maturo, C.C. and Narayan, K.M.V., 2012. Is there evidence that friends influence body weight? A systematic review of empirical research. *Social Science & Medicine*, 75(7), pp.1175–83.

Dallal, R.M., Quebbemann, B.B., Hunt, L.H. and Braitman, L.E., 2009. Analysis of weight loss after bariatric surgery using mixed-effects linear modelling. *Obesity Surgery*, 19(6), pp.732–7.

Delin, C.R., Watts, J.M.W. and Bassett, D.L., 1995. An Exploration of the Outcomes of Gastric Bypass Surgery for Morbid Obesity: Patient Characteristics and Indices of Success. *Obesity Surgery*, 5(2), pp.159–170.

DeSocio, J., Kitzman, H. and Cole, R., 2003. Testing the relationship between self-agency and enactment of health behaviors. *Research in Nursing & Health*, 26(1), pp.20–9.

Dierk, J.-M., Conradt, M., Rauh, E., Schlumberger, P., Hebebrand, J. and Rief, W., 2006. What determines well-being in obesity? Associations with BMI, social skills, and social support. *Journal of Psychosomatic Research*, 60(3), pp.219–227.

DiMatteo, M.R., 2004. Social support and patient adherence to medical treatment: a meta-analysis. *Health Psychology*, 23(2), pp.207–18.

Dinour, L., Leung, M.M., Tripicchio, G., Khan, S. and Yeh, M.-C., 2012. The Association between Marital Transitions, Body Mass Index, and Weight: A Review of the Literature. *Journal of Obesity*, 2012, p.294974.

Dixon, J.B., McPhail, T. and O'Brien, P.E., 2005. Minimal reporting requirements for weight loss: current methods not ideal. *Obesity Surgery*, 15(7), pp.1034–9.

Douglas, I.J., Bhaskaran, K., Batterham, R.L. and Smeeth, L., 2015. Bariatric Surgery in the United Kingdom: A Cohort Study of Weight Loss and Clinical Outcomes in Routine Clinical Care. *PLoS Medicine*, 12(12), p.e1001925.

De Dreu, C.K.W. and Kret, M.E., 2016. Oxytocin Conditions Intergroup Relations Through Upregulated In-Group Empathy, Cooperation, Conformity, and Defense. *Biological Psychiatry*, 79(3), pp.165–173.

Dugravot, A., Sabia, S., Stringhini, S., Kivimaki, M., Westerlund, H., Vahtera, J., Guéguen, A., et al., 2010. Do socioeconomic factors shape weight and obesity trajectories over the transition from midlife to old age? Results from the French GAZEL cohort study. *The American Journal of Clinical Nutrition*, 92(1), pp.16–23.

Eisenberger, N.I., 2013. An empirical review of the neural underpinnings of receiving and giving social support: implications for health. *Psychosomatic Medicine*, 75(6), pp.545–56.

Elakkary, E., Elhorr, A., Aziz, F., Gazayerli, M.M. and Silva, Y.J., 2006. Do support groups play a role in weight loss after laparoscopic adjustable gastric banding? *Obesity Surgery*, 16(3), pp.331–4.

Elfhag, K. and Rössner, S., 2005. Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and weight regain. *Obesity Reviews*, 6(1), pp.67–85.

Elsner, R.J.F., 2002. Changes in eating behavior during the aging process. *Eating Behaviors*, 3(1), pp.15–43.

Eng, P.M., Kawachi, I., Fitzmaurice, G. and Rimm, E.B., 2005. Effects of marital transitions on changes in dietary and other health behaviours in US male health professionals. *Journal of Epidemiology & Community Health*, 59(1), pp.56–62.

Farr, W., 1858. The influence of marriage on the mortality of the French People. *Transactions of the National Association for the Promotion of Social Science*, 504.

Feldman, R., Monakhov, M., Pratt, M. and Ebstein, R.P., 2016. Oxytocin Pathway Genes: Evolutionary Ancient System Impacting on Human Affiliation, Sociality, and Psychopathology. *Biological Psychiatry*, 79(3), pp.174–184.

Fingerman, K.L., Hay, E.L. and Birditt, K.S., 2004. The Best of Ties, the Worst of Ties: Close, Problematic, and Ambivalent Social Relationships. *Journal of Marriage and Family*, 66(3), pp.792–808.

Finucane, M.M., Stevens, G.A., Cowan, M.J., Danaei, G., Lin, J.K., Paciorek, C.J., Singh, G.M., Gutierrez, H.R., et al., 2011. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. *The Lancet*, 377(9765), pp.557–67.

Fiori, K.L., Antonucci, T.C. and Cortina, K.S., 2006. Social network typologies and mental health among older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 61(1), pp.25–32.

Folsom, A.R., Kushi, L.H., Anderson, K.E., Mink, P.J., Olson, J.E., Hong, C.-P., Sellers, T.A., Lazovich, D. and Prineas, R.J., 2000. Associations of General and Abdominal Obesity With Multiple Health Outcomes in Older Women. *Archives of Internal Medicine*, 160(14), p.2117.

Friedman, E.M., Karlamangla, A.S., Almeida, D.M. and Seeman, T.E., 2012. Social strain and cortisol regulation in midlife in the US. *Social Science & Medicine*, 74(4), pp.607–15.

Fuhrer, R. and Stansfeld, S.A., 2002. How gender affects patterns of social relations and their impact on health: a comparison of one or multiple sources of support from 'close persons'. *Social Science & Medicine*, 54(5), pp.811–825.

Fuhrer, R., Stansfeld, S.A., Chemali, J. and Shipley, M.J., 1999. Gender, social relations and mental health: prospective findings from an occupational cohort (Whitehall II study). *Social Science & Medicine*, 48(1), pp.77–87.

Fung, H.H., Yeung, D.Y., Li, K.-K. and Lang, F.R., 2009. Benefits of negative social exchanges for emotional closeness. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 64(5), pp.612–21.

Gallo, L.C., Troxel, W.M., Matthews, K.A., Kuller, L.H., 2003. Marital status and quality in middle-aged women: Associations with levels and trajectories of cardiovascular risk factors. *Health Psychology*, 22(5), pp.453–63.

Gaysina, D., Hotopf, M., Richards, M., Colman, I., Kuh, D. and Hardy, R., 2011. Symptoms of depression and anxiety, and change in body mass index from adolescence to adulthood: results from a British birth cohort. *Psychological Medicine*, 41(1), pp.175–84.

van Gemert, W.G., Severeijns, R.M., Greve, J.W., Groenman, N. and Soeters, P.B., 1998. Psychological functioning of morbidly obese patients after surgical treatment. *International Journal of Obesity and Related Metabolic Disorders*, 22(5), pp.393–8.

Geraci, A.A., Brunt, A.R. and Marihart, C.L., 2014. Social Support Systems: A Qualitative Analysis of Female Bariatric Patients After the First Two Years Postoperative. *Bariatric Surgical Practice and Patient Care*, 9(2), pp.66–71.

Gloy, V.L., Briel, M., Bhatt, D.L., Kashyap, S.R., Schauer, P.R., Mingrone, G., Bucher, H.C. and Nordmann, A.J., 2013. Bariatric surgery versus non-surgical treatment for obesity: a systematic review and meta-analysis of randomised controlled trials. *BMJ*, 347, p.f5934.

Goble, L., Rand, C. and Kuldau, J., 1986. Understanding marital relationships following obesity surgery. *Family Therapy*, 13(2), p.195.

Gottlieb, B.H. and Bergen, A.E., 2010. Social support concepts and measures. *Journal of Psychosomatic Research*, 69(5), pp.511–520.

Gow, A.J., Corley, J., Starr, J.M. and Deary, I.J., 2013. Which Social Network or Support Factors are Associated with Cognitive Abilities in Old Age? *Gerontology*, 59(5), pp.454–463.

Grewen, K.M., Girdler, S.S., Amico, J. and Light, K.C., 2005. Effects of Partner Support on Resting Oxytocin, Cortisol, Norepinephrine, and Blood Pressure Before and After Warm Partner Contact. *Psychosomatic Medicine*, 67(4), pp.531–538.

Gruenewald, T.L., Liao, D.H. and Seeman, T.E., 2012. Contributing to Others, Contributing to Oneself: Perceptions of Generativity and Health in Later Life. *The Journals of Gerontology Series B: Psychological Sciences and Social* Sciences, 67(6), pp.660–665.

Guh, D.P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C.L. and Anis, A.H., 2009. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health*, 9(1), p.88.

Hachem, A. and Brennan, L., 2016. Quality of Life Outcomes of Bariatric Surgery: A Systematic Review. *Obesity Surgery*, 26(2), pp.395–409.

Hafner, R.J., Rogers, J. and Watts, J.M., 1990. Psychological status before and after gastric restriction as predictors of weight loss in the morbidly obese. *Journal of Psychosomatic Research*, 34(3), pp.295–302.

Hamburg, M.E., Finkenauer, C. and Schuengel, C., 2014. Food for love: the role of food offering in empathic emotion regulation. *Frontiers in Psychology*, 5, p.32.

Hammond, R.A., 2010. Social influence and obesity. *Current Opinion in Endocrinology, Diabetes, and Obe*sity, 17(5), pp.467–71.

Harvey, I.S. and Alexander, K., 2012. Perceived social support and preventive health behavioral outcomes among older women. *Journal of Cross-Cultural Gerontology*, 27(3), pp.275–90.

Harvin, G., DeLegge, M. and Garrow, D.A., 2008. The impact of race on weight loss after Roux-en-Y gastric bypass surgery. *Obesity Surgery*, 18(1), pp.39–42.

Hatoum, I.J. and Kaplan, L.M., 2013. Advantages of percent weight loss as a method of reporting weight loss after Roux-en-Y gastric bypass. *Obesity*, 21(8), pp.1519–25.

Hawkley, L.C. and Cacioppo, J.T., 2003. Loneliness and pathways to disease. *Brain, Behavior, and Immunity*, 17 (Suppl 1), pp.S98–S105.

He, X.Z. and Baker, D.W., 2004. Changes in weight among a nationally representative cohort of adults aged 51 to 61, 1992 to 2000. *American Journal of Preventive Medicine*, 27(1), pp.8–15.

Heineck, G., 2006. Height and weight in Germany, evidence from the German Socio-Economic Panel, 2002. *Economics and Human Biology*, 4(3), pp.359–82.

Hemström, O., 1996. Marriage Dissolution Linked to Differences in Mortality Risks for Men and Women? *Journal of Marriage and Family*, 58(2), pp.366–378.

Herpertz, S., Kielmann, R., Wolf, A.M., Langkafel, M., Senf, W. and Hebebrand, J., 2003. Does obesity surgery improve psychosocial functioning? A systematic review. *International Journal of Obesity and Related Metabolic Disorders*, 27(11), pp.1300–14.

Hildebrandt, E., 1998. Effects of Participation Group After Roux-en-Y in Bariatric Support Gastric Bypass. *Obesity Surgery*, 8(5), pp.535–542.

Holahan, C.K. and Holahan, C.J., 1987. Self-efficacy, social support, and depression in aging: a longitudinal analysis. *Journal of Gerontology*, 42(1), pp.65–8.

Holt-Lunstad, J., Smith, T.B. and Layton, J.B., 2010. Social relationships and mortality risk: a meta-analytic review. *PLoS Medicine*, 7(7), p.e1000316.

Holtgrave, D.R. and Crosby, R., 2006. Is social capital a protective factor against obesity and diabetes? Findings from an exploratory study. *Annals of Epidemiology*, 16(5), pp.406–408.

Hörchner, R., Tuinebreijer, W.E., Kelder, H. and van Urk, E., 2002. Coping behavior and loneliness among obese patients. *Obesity Surgery*, 12(6), pp.864–8.

House, J.S., Landis, K.R. and Umberson, D., 1988. Social Relationships and Health. *Science*, 241(4865), pp.540–545.

van Hout, G.C.M., Boekestein, P., Fortuin, F.A.M., Pelle, A.J.M. and van Heck, G.L., 2006. Psychosocial functioning following bariatric surgery. *Obesity Surgery*, 16(6), pp.787–94.

van Hout, G.C.M., Verschure, S.K.M. and van Heck, G.L., 2005. Psychosocial predictors of success following bariatric surgery. *Obesity Surgery*, 15(4), pp.552–60.

Hu, G., Tuomilehto, J., Silventoinen, K., Barengo, N.C., Peltonen, M. and Jousilahti, P., 2005. The effects of physical activity and body mass index on cardiovascular, cancer and all-cause mortality among 47 212 middle-aged Finnish men and women. *International Journal of Obesity*, 29(8), pp.894–902.

Hughes, V.A., Roubenoff, R., Wood, M., Frontera, W.R., Evans, W.J. and Fiatarone Singh, M.A., 2004. Anthropometric assessment of 10-y changes in body composition in the elderly. *The American Journal of Clinical Nutri*tion, 80(2), pp.475–82.

Hulmán, A., Tabák, A.G., Nyári, T.A., Vistisen, D., Kivimäki, M., Brunner, E.J. and Witte, D.R., 2014. Effect of secular trends on age-related trajectories of cardiovascular risk factors: the Whitehall II longitudinal study 1985-2009. *International Journal of Epidemiology*, 43(3), pp.866–77.

Huppert, F.A. and Whittington, J.E., 1995. Symptoms of psychological distress predict 7-year mortality. *Psychological Medicine*, 25(5), pp.1073–86.

Huxley, R., Mendis, S., Zheleznyakov, E., Reddy, S. and Chan, J., 2010. Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk--a review of the literature. *European Journal of Clinical Nutrition*, 64(1), pp.16–22.

Hwang, K.O., Childs, J.H., Goodrick, G.K., Aboughali, W.A., Thomas, E.J., Johnson, C.W., Yu, S.C. and Bernstam, E. V, 2009. Explanations for unsuccessful weight loss among bariatric surgery candidates. *Obesity Surgery*, 19(10), pp.1377–1383.

Iemolo, A., Blasio, A., St Cyr, S.A., Jiang, F., Rice, K.C., Sabino, V. and Cottone, P., 2013. CRF–CRF1 Receptor System in the Central and Basolateral Nuclei of the Amygdala Differentially Mediates Excessive Eating of Palatable Food. *Neuropsychopharmacology*, 38(12), pp.2456–2466.

Ikeda, A., Kawachi, I., Iso, H., Iwasaki, M., Inoue, M. and Tsugane, S., 2013. Social support and cancer incidence and mortality: the JPHC study cohort II. *Cancer Causes & Control*, 24(5), pp.847–60.

Inagaki, T.K., Bryne Haltom, K.E., Suzuki, S., Jevtic, I., Hornstein, E., Bower, J.E. and Eisenberger, N.I., 2016. The Neurobiology of Giving Versus Receiving Support: The Role of Stress-Related and Social Reward-Related Neural Activity. *Psychosomatic Medicine*, 78(4), pp.443–53.

Inagaki, T.K. and Eisenberger, N.I., 2012. Neural Correlates of Giving Support to a Loved One. *Psychosomatic Medicine*, 74(1), pp.3–7.

Inagaki, T.K. and Eisenberger, N.I., 2016. Giving support to others reduces sympathetic nervous system-related responses to stress. *Psychophysiology*, 53(4), pp.427–35.

Jacobsen, B.K., Njølstad, I., Thune, I., Wilsgaard, T., Løchen, M.-L. and Schirmer, H., 2001. Increase in Weight in All Birth Cohorts in a General Population. *Archives of Internal Medicine*, 161(3), p.466.

Jagielski, A.C., Brown, A., Hosseini-Araghi, M., Thomas, G.N. and Taheri, S., 2014. The association between adiposity, mental well-being, and quality of life in extreme obesity. *PloS One*, 9(3), p.e92859.

Janghorbani, M., Amini, M., Rezvanian, H., Gouya, M.M., Delavari, A., Alikhani, S. and Mahdavi, A., 2008. Association of body mass index and abdominal obesity with marital status in adults. *Archives of Iranian Medicine,* 11(3), pp.274–281.

Jeffery, R.W. and Rick, A.M., 2002. Cross-sectional and longitudinal associations between body mass index and marriage-related factors. *Obesity Research*, 10(8), pp.809–15.

Jensen, J.F., Rauer, A.J. and Volling, B., 2013. A Dyadic View of Support in Marriage: The Critical Role of Men's Support Provision. *Sex Roles*, 68(7–8), pp.427–438.

Johnson, N.J., Backlund, E., Sorlie, P.D. and Loveless, C.A., 2000. Marital status and mortality: the national longitudinal mortality study. *Annals of Epidemiology*, 10(4), pp.224–38.

Johnson, W., Li, L., Kuh, D. and Hardy, R., 2015. How Has the Age-Related Process of Overweight or Obesity Development Changed over Time? Co-ordinated Analyses of Individual Participant Data from Five United Kingdom Birth Cohorts. *PLoS Medicine*, 12(5), p.e1001828.

Kahng, S.K., Dunkle, R.E. and Jackson, J.S., 2004. The Relationship Between the Trajectory of Body Mass Index and Health Trajectory Among Older Adults: Multilevel Modeling Analyses. *Research on Aging*, 26(1), pp.31–61.

Karamanakos, S.N., Vagenas, K., Kalfarentzos, F. and Alexandrides, T.K., 2008. Weight loss, appetite suppression, and changes in fasting and postprandial ghrelin and peptide-YY levels after Roux-en-Y gastric bypass and sleeve gastrectomy: a prospective, double blind study. *Annals of Surgery*, 247(3), pp.401–7.

Karlsson, J., Sjöström, L. and Sullivan, M., 1998. Swedish obese subjects (SOS)--an intervention study of obesity. Two-year follow-up of health-related quality of life (HRQL) and eating behavior after gastric surgery for severe obesity. *International Journal of Obesity and Related Metabolic Disorders*, 22(2), pp.113–26.

Karmali, S., Birch, D.W. and Sharma, A.M., 2009. Is it time to abandon excess weight loss in reporting surgical weight loss? *Surgery for Obesity and Related Diseases*, 5(4), pp.503–6.

Kaye, S.A., Folsom, A.R., Jacobs, D.R., Hughes, G.H. and Flack, J.M., 1993. Psychosocial correlates of body fat distribution in black and white young adults. *International Journal of Obesity and Related Metabolic Disorders*, 17(5), pp.271–7.

Kellogg, T.A., 2011. Revisional bariatric surgery. *The Surgical Clinics of North America*, 91(6), pp.1353–71.

Kershaw, K.N., Hankinson, A.L., Liu, K., Reis, J.P., Lewis, C.E., Loria, C.M. and Carnethon, M.R., 2014. Social relationships and longitudinal changes in body mass index and waist circumference: the coronary artery risk development in young adults study. *American Journal of Epidemiology*, 179(5), pp.567–75.

Khaitan, L., Van Sickle, K., Gonzalez, R., Lin, E., Ramshaw, B. and Smith, C.D., 2005. Laparoscopic revision of bariatric procedures: is it feasible? *The American Surgeon*, 71(1), pp.6-10–2.

Khaodhiar, L., McCowen, K.C. and Blackburn, G.L., 1999. Obesity and its comorbid conditions. *Clinical Cornerstone*, 2(3), pp.17–31.

Kiecolt-Glaser, J.K. and Newton, T.L., 2001. Marriage and health: his and hers. *Psychological Bulletin*, 127(4), pp.472–503.

Kim, I.-H., Chun, H. and Kwon, J.-W., 2011. Gender differences in the effect of obesity on chronic diseases among the elderly Koreans. *Journal of Korean Medical Science*, 26(2), pp.250–7.

Kivimäki, M., Jokela, M., Hamer, M., Geddes, J., Ebmeier, K., Kumari, M., Singh-Manoux, A., Hingorani, A. and Batty, G.D., 2011. Examining overweight and obesity as risk factors for common mental disorders using fat mass and obesity-associated (FTO) genotype-instrumented analysis: The Whitehall II Study, 1985-2004. *American Journal of Epidemiology*, 173(4), pp.421–9.

Kivimäki, M., Lawlor, D.A., Singh-Manoux, A., Batty, G.D., Ferrie, J.E., Shipley, M.J., Nabi, H., Sabia, S., Marmot, M.G. and Jokela, M., 2009. Common mental disorder and obesity: insight from four repeat measures over 19 years: prospective Whitehall II cohort study. *BMJ*, 339, p.b3765.

Koenig, H.G., 2007. Altruistic Love and Physical Healt. In: S.G., Post, ed., *Altruism and health: Perspectives from empirical research*, 1st ed. New York: Oxford University Press.

Kolotkin, R.L., Meter, K. and Williams, G.R., 2001. Quality of life and obesity. *Obesity Reviews*, 2(4), pp.219–29.

Komlos, J. and Brabec, M., 2011. The trend of BMI values of US adults by deciles, birth cohorts 1882-1986 stratified by gender and ethnicity. *Economics and Human Biology*, 9(3), pp.234–50.

Kosfeld, M., Heinrichs, M., Zak, P.J., Fischbacher, U. and Fehr, E., 2005. Oxytocin increases trust in humans. *Nature*, 435(7042), pp.673–676.

Koster, A., Leitzmann, M.F., Schatzkin, A., Mouw, T., Adams, K.F., van Eijk, J.T.M., Hollenbeck, A.R. and Harris, T.B., 2008. Waist circumference and mortality. *American Journal of Epidemiology*, 167(12), pp.1465–75.

Kouvonen, A., Stafford, M., De Vogli, R., Shipley, M.J., Marmot, M.G., Cox, T., Vahtera, J., Väänänen, A., Heponiemi, T., Singh-Manoux, A. and Kivimäki, M., 2011. Negative aspects of close relationships as a predictor of increased body mass index and waist circumference: the Whitehall II study. *American Journal of Public Health*, 101(8), pp.1474–80.

Kouvonen, A., De Vogli, R., Stafford, M., Shipley, M.J., Marmot, M.G., Cox, T., Vahtera, J., Väänänen, A., Heponiemi, T., Singh-Manoux, A. and Kivimäki, M., 2012. Social support and the likelihood of maintaining and improving levels of physical activity: the Whitehall II Study. *European Journal of Public Health*, 22(4), pp.514–8.

Krause, N., 1995. Negative interaction and satisfaction with social support among older adults. The *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 50(2), pp.59-73.

Krause, N., 1999. Assessing Change in Social Support During Late Life. *Research on Aging,* 21(4), pp.539–569.

Krause, N., 2016. Providing emotional support to others, self-esteem, and self-rated health. *Archives of Gerontology and Geriatrics*, 65, pp.183–191.

Krause, N., Herzog, A.R. and Baker, E., 1992. Providing support to others and well-being in later life. *Journal of Gerontology*, 47(5), pp.300-11.

Krause, N. and Markides, K., 1990. Measuring social support among older adults. *International Journal of Aging & Human Development*, 30(1), pp.37–53.

Krause, N. and Shaw, B.A., 2000. Giving social support to others, socioeconomic status, and changes in self-esteem in late life. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 55(6), pp.S323-33.

Kroenke, C.H., Kubzansky, L.D., Schernhammer, E.S., Holmes, M.D. and Kawachi, I., 2006. Social networks, social support, and survival after breast cancer diagnosis. *Journal of Clinical Oncology*, 24(7), pp.1105–11.

Kuchibhatla, M.N., Fillenbaum, G.G., Kraus, W.E., Cohen, H.J. and Blazer, D.G., 2013. Trajectory classes of body mass index in a representative elderly community sample. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, 68(6), pp.699–704.

Kuk, J.L., Saunders, T.J., Davidson, L.E. and Ross, R., 2009. Age-related changes in total and regional fat distribution. *Ageing Research Reviews*, 8(4), pp.339–48.

Kumari, M., Chandola, T., Brunner, E. and Kivimaki, M., 2010. A nonlinear relationship of generalized and central obesity with diurnal cortisol secretion in the Whitehall II study. *The Journal of Clinical Endocrinology and Metabolism*, 95(9), pp.4415–4423.

Kvalem, I.L., Bergh, I., von Soest, T., Rosenvinge, J.H., Johnsen, T.A., Martinsen, E.W., Mala, T. and Kristinsson, J.A., 2015. A comparison of behavioral and psychological characteristics of patients opting for surgical and conservative treatment for morbid obesity. *BMC Obesity*, 3(1), p.6.

van de Laar, A., 2012. Bariatric Outcomes Longitudinal Database (BOLD) suggests excess weight loss and excess BMI loss to be inappropriate outcome measures, demonstrating better alternatives. *Obesity Surgery*, 22(12), pp.1843–7.

van de Laar, A., de Caluwé, L. and Dillemans, B., 2011. Relative outcome measures for bariatric surgery. Evidence against excess weight loss and excess body mass index loss from a series of laparoscopic Roux-en-Y gastric bypass patients. *Obesity Surgery*, 21(6), pp.763–7.

Lakey, B. and Cohen, S., 2000. Social Support Theory and Measurement. In: S., Cohen, G.L., Underwood and H.B., Gottlieb, eds., *Social Support Measurement and Intervention: A Guide for Health and Social Scientists*. New York: Oxford University Press.

Lakey, B. and Orehek, E., 2011. Relational regulation theory: A new approach to explain the link between perceived social support and mental health. *Psychological Review*, 118(3), pp.482–495.

Lakey, B. and Rhodes, G., 2015. The social regulation of affect and self-esteem among opiate-dependent adults. *Personal Relationships*, 22(1), pp.111–121.

Langford, C.P., Bowsher, J., Maloney, J.P. and Lillis, P.P., 1997. Social support: a conceptual analysis. *Journal of Advanced Nursing*, 25(1), pp.95–100.

Lanyon, R.I. and Maxwell, B.M., 2007. Predictors of outcome after gastric bypass surgery. *Obesity Surgery*, 17(3), pp.321–8.

Lashewicz, B., Lo, A., Mooney, L. and Khan, H., 2012. Drawing the Line: A Case Study of Ambivalence in Sibling Support for Adults with Complex Needs. *Issues in Mental Health Nursing,* 33(11), pp.727–734.

Lauder, W., Mummery, K., Jones, M. and Caperchione, C., 2006. A comparison of health behaviours in lonely and non-lonely populations. *Psychology, Health & Medicine*, 11(2), pp.233–245.

Lauderdale, D.S., Knutson, K.L., Rathouz, P.J., Yan, L.L., Hulley, S.B. and Liu, K., 2009. Cross-sectional and Longitudinal Associations Between Objectively Measured Sleep Duration and Body Mass Index: The CARDIA Sleep Study. *American Journal of Epidemiology*, 170(7), pp.805–813.

Leahey, T.M., Doyle, C.Y., Xu, X., Bihuniak, J. and Wing, R.R., 2015. Social networks and social norms are associated with obesity treatment outcomes. *Obesity*, 23(8), pp.1550–4.

Lee, C.G., Boyko, E.J., Nielson, C.M., Stefanick, M.L., Bauer, D.C., Hoffman, A.R., Dam, T.-T.L., Lapidus, J.A., Cawthon, P.M., Ensrud, K.E. and Orwoll, E.S., 2011. Mortality risk in older men associated with changes in weight, lean mass, and fat mass. *Journal of the American Geriatrics Society*, 59(2), pp.233–40.

Lee, S., Cho, E., Grodstein, F., Kawachi, I., Hu, F.B. and Colditz, G.A., 2005. Effects of marital transitions on changes in dietary and other health behaviours in US women. *International Journal of Epidemiology*, 34(1), pp.69–78.

Leroux, J.S., Moore, S. and Dubé, L., 2013. Beyond the 'I' in the Obesity Epidemic: A Review of Social Relational and Network Interventions on Obesity. *Journal of Obesity*, 2013, p.348249.

Lett, H.S., Blumenthal, J.A., Babyak, M.A., Strauman, T.J., Robins, C. and Sherwood, A., 2005. Social support and coronary heart disease: epidemiologic evidence and implications for treatment. *Psychosomatic Medicine*, 67(6), pp.869–78.

Lewis, M.A. and Butterfield, R.M., 2007. Social Control in Marital Relationships: Effect of One's Partner on Health Behaviors. *Journal of Applied Social Psychology*, 37(2), pp.298–319.

Li, J.-F., Lai, D.-D., Ni, B. and Sun, K.-X., 2013. Comparison of laparoscopic Roux-en-Y gastric bypass with laparoscopic sleeve gastrectomy for morbid obesity or type 2 diabetes mellitus: a meta-analysis of randomized controlled trials. *Canadian Journal of Surgery*, 56(6), pp.E158-64.

Liang, J., Krause, N.M. and Bennett, J.M., 2001. Social exchange and well-being: is giving better than receiving? *Psychology and Aging*, 16(3), pp.511–23.

Liao, J., Head, J., Kumari, M., Stansfeld, S., Kivimaki, M., Singh-Manoux, A. and Brunner, E.J., 2014. Negative aspects of close relationships as risk factors for cognitive aging. *American Journal of Epidemiology,* 180(11), pp.1118–25.

Liebl, L., Barnason, S. and Brage Hudson, D., 2016. Awakening: a qualitative study on maintaining weight loss after bariatric surgery. *Journal of Clinical Nursing*, 25(7–8), pp.951–61.

Light, K.C., Grewen, K.M. and Amico, J.A., 2005. More frequent partner hugs and higher oxytocin levels are linked to lower blood pressure and heart rate in premenopausal women. *Biological Psychology*, 69(1), pp.5–21.

Lillard, L.A. and Waite, L.J., 1995. Til Death Do Us Part: Marital Disruption and Mortality. *American Journal of Sociology*, 100(5), pp.1131–1156.

Liu, H. and Umberson, D.J., 2008. The times they are a changin': marital status and health differentials from 1972 to 2003. *Journal of Health and Social Behavior*, 49(3), pp.239–53.

Livhits, M., Mercado, C., Yermilov, I., Parikh, J.A., Dutson, E., Mehran, A., Ko, C.Y. and Gibbons, M.M., 2012. Preoperative predictors of weight loss following bariatric surgery: systematic review. *Obesity Surgery*, 22(1), pp.70–89.

Livhits, M., Mercado, C., Yermilov, I., Parikh, J. a, Dutson, E., Mehran, A., Ko, C.Y. and Gibbons, M.M., 2010. Behavioral factors associated with successful weight loss after gastric bypass. *The American Surgeon,* 76(10), pp.1139–42.

Livhits, M., Mercado, C., Yermilov, I., Parikh, J. a, Dutson, E., Mehran, Ko, C.Y., Shekelle, P.G. and Gibbons, M.M., 2011. Is social support associated with greater weight loss after bariatric surgery? A systematic review. *Obesity Reviews*, 12(2), pp.142–148.

Locher, J.L., Roth, D.L., Ritchie, C.S., Cox, K., Sawyer, P., Bodner, E. V and Allman, R.M., 2007. Body mass index, weight loss, and mortality in community-dwelling older adults. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, 62(12), pp.1389–92.

Loucks, E.B., Berkman, L.F., Gruenewald, T.L. and Seeman, T.E., 2006. Relation of social integration to inflammatory marker concentrations in men and women 70 to 79 years. *The American Journal of Cardiology*, 97(7), pp.1010–1016.

Luo, Y., Hawkley, L.C., Waite, L.J. and Cacioppo, J.T., 2012. Loneliness, health, and mortality in old age: a national longitudinal study. *Social Science & Medicine*, 74(6), pp.907–14.

Lutfi, R., Torquati, A., Sekhar, N. and Richards, W.O., 2006. Predictors of success after laparoscopic gastric bypass: a multivariate analysis of socioeconomic factors. *Surgical Endoscopy*, 20(6), pp.864–7.

MacInnis, R.J., Hodge, A.M., Dixon, H.G., Peeters, A., Johnson, L.E., English, D.R. and Giles, G.G., 2014. Predictors of increased body weight and waist circumference for middle-aged adults. *Public Health Nutrition*, 17(5), pp.1087–97.

MacPherson, K., Marsh, T. and Brown, M., 2007. *Tackling Obesities: Future Choices – Modelling future trends in obesity and the impact on health*. London: Government Office for Science.

Maggard, M.A., 2005. Meta-Analysis: Surgical Treatment of Obesity. *Annals of Internal Medicine*, 142(7), p.547-559.

Magro, D.O., Geloneze, B., Delfini, R., Pareja, B.C., Callejas, F. and Pareja, J.C., 2008. Long-term Weight Regain after Gastric Bypass: A 5-year Prospective Study. *Obesity Surgery*, 18(6), pp.648–651.

Makaronidis, J.M. and Batterham, R.L., 2016. Potential Mechanisms Mediating Sustained Weight Loss Following Roux-en-Y Gastric Bypass and Sleeve Gastrectomy. *Endocrinology and Metabolism Clinics of North America*, 45(3), pp.539–552.

Manning, S., Pucci, A., Carter, N.C., Elkalaawy, M., Querci, G., Magno, S., Tamberi, A., Finer, N., Fiennes, A.G., Hashemi, M., Jenkinson, A.D., Anselmino, M., Santini, F., Adamo, M. and Batterham, R.L., 2015. Early postoperative weight loss predicts maximal weight loss after sleeve gastrectomy and Roux-en-Y gastric bypass. *Surgical Endoscopy*, 29(6), pp.1484–91.

Manzoli, L., Villari, P., M Pirone, G. and Boccia, A., 2007. Marital status and mortality in the elderly: a systematic review and meta-analysis. *Social Science & Medicine* (1982), 64(1), pp.77–94.

Marmot, M. and Brunner, E., 2005. Cohort Profile: the Whitehall II study. *International Journal of Epidemiology*, 34(2), pp.251–256.

Marshall, D.W. and Anderson, A.S., 2002. Proper meals in transition: young married couples on the nature of eating together. *Appetite*, 39(3), pp.193–206.

Mata, J., Frank, R. and Hertwig, R., 2015. Higher body mass index, less exercise, but healthier eating in married adults: Nine representative surveys across Europe. *Social Science & Medicine*, 138(2005), pp.119–27.

McDowell, M.A., Fryar, C.D., Ogden, C.L. and Flegal, K.M., 2008. Anthropometric reference data for children and adults: United States, 2003–2006. *National Health Statistics Reports*, 11(249), pp.1–48.

McMahon, M.M., Sarr, M.G., Clark, M.M., Gall, M.M., Knoetgen, J., Service, F.J., Laskowski, E.R. and Hurley, D.L., 2006. Clinical Management After Bariatric Surgery: Value of a Multidisciplinary Approach. *Mayo Clinic Proceedings*, 81(10), pp.S34–S45.

Meltzer, A.L., Novak, S.A., McNulty, J.K., Butler, E.A. and Karney, B.R., 2013. Marital satisfaction predicts weight gain in early marriage. *Health Psychology*, 32(7), pp.824–7.

Miranda, W.R., Batsis, J.A., Sarr, M.G., Collazo-Clavell, M.L., Clark, M.M., Somers, V.K. and Lopez-Jimenez, F., 2013. Impact of bariatric surgery on quality of life, functional capacity, and symptoms in patients with heart failure. *Obesity Surgery*, 23(7), pp.1011–5.

Monkhouse, S., Choudry, M. and Woodcock, S., 2013. Do Bariatric Patient Support Groups Influence Short-Term Surgical Outcomes? An Investigation into the True Value of Bariatric Patient Support Groups. *Bariatric Surgical Practice and Patient Care*, 8(3), pp.94–98.

Montero, P.N., Stefanidis, D., Norton, H.J., Gersin, K. and Kuwada, T., 2011. Reported excess weight loss after bariatric surgery could vary significantly depending on calculation method: a plea for standardization. *Surgery for Obesity and Related Diseases*, 7(4), pp.531–4.

Moore, D.D. and Cooper, C.E., 2016. Life After Bariatric Surgery: Perceptions of Male Patients and Their Intimate Relationships. *Journal of Marital and Family Therapy*, 42(3), pp.495–508.

Moore, S., 2010. Social Networks, Social Capital and Obesity: A Literature Review. In: L., Dube, A., Bechara, A., Dagher, A., Drewnowski, J., LeBel, P.,James and R., Yada, eds., *Obesity Prevention Handbook: The Role of Society and Brain on Individual Behavior*. London: Elsevier.

Moore, S., Daniel, M., Paquet, C., Dubé, L. and Gauvin, L., 2009. Association of individual network social capital with abdominal adiposity, overweight and obesity. *Journal of Public Health*, 31(1), pp.175–183.

Morelli, S.A., Lee, I.A., Arnn, M.E. and Zaki, J., 2015. Emotional and instrumental support provision interact to predict well-being. *Emotion*, 15(4), pp.484–93.

Murayama, H., Liang, J., Bennett, J.M., Shaw, B.A., Botoseneanu, A., Kobayashi, E., Fukaya, T. and Shinkai, S., 2015. Trajectories of Body Mass Index and Their Associations With Mortality Among Older Japanese: Do They Differ From Those of Western Populations? *American Journal of Epidemiology*, 182(7), pp.597–605.

Murayama, H., Liang, J., Bennett, J.M., Shaw, B.A., Botoseneanu, A., Kobayashi, E., Fukaya, T. and Shinkai, S., 2016. Socioeconomic Status and the Trajectory of Body Mass Index Among Older Japanese: A Nationwide Cohort Study of 1987-2006. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences,* 71(2), pp.378–88.

Myrskylä, M. and Chang, V.W., 2009. Weight change, initial BMI, and mortality among middle- and older-aged adults. *Epidemiology*, 20(6), pp.840–8.

National Institute for Health and Care Excellence, 2014. *Identification, assessment and management of overweight and obesity in children, young people and adults.* London. Available from: https://www.nice.org.uk/guidance/cg189/chapter/1-recommendations#identification-and-classification-of-overweight-and-obesity.

Nelbom, B., Naver, L., Ladelund, S. and Hornnes, N., 2010. Patient Characteristics Associated with a Successful Weight Loss after Bariatric Surgery. *Bariatric Nursing and Surgical Patient Care*, 5(4), pp.313–319.

Newman, A.B., Yanez, D., Harris, T., Duxbury, A., Enright, P.L. and Fried, L.P., 2001. Weight change in old age and its association with mortality. *Journal of the American Geriatrics Society*, 49(10), pp.1309–18.

Ng, M., Fleming, T., Robinson, M., et al., 2016. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *The Lancet*, 388(10046), pp.776–786.

Nooyens, A.C.J., Visscher, T.L.S., Verschuren, W.M.M., Schuit, A.J., Boshuizen, H.C., van Mechelen, W. and Seidell, J.C., 2009. Age, period and cohort effects on body weight and body mass index in adults: The Doetinchem Cohort Study. *Public Health Nutrition,* 12(6), pp.862–70.

Nordin, M., Knutsson, A. and Sundbom, E., 2008. Is Disturbed Sleep a Mediator in the Association between Social Support and Myocardial Infarction? *Journal of Health Psychology*, 13(1), pp.55–64.

Novak, S.A. and Webster, G.D., 2011. Spousal Social Control During a Weight Loss Attempt: A Daily Diary Study. *Personal Relationships*, 18(2), pp.224–241.

Novin, S., Tso, I.F. and Konrath, S.H., 2014. Self-Related and Other-Related Pathways to Subjective Well-Being in Japan and the United States. *Journal of Happiness Studies*, 15(5), pp.995–1014.

Obeidat, F. and Shanti, H., 2016. Early Weight Loss as a Predictor of 2-Year Weight Loss and Resolution of Comorbidities After Sleeve Gastrectomy. *Obesity Surgery*, 26(6), pp.1173–7.

Ogden, C.L., Fryar, C.D., Carroll, M.D. and Flegal, K.M., 2004. Mean body weight, height, and body mass index, United States 1960-2002. *Advance Data*, (347), pp.1–17.

Ogden, J., Hollywood, A. and Pring, C., 2015. The impact of psychological support on weight loss post weight loss surgery: a randomised control trial. *Obesity Surgery*, 25(3), pp.500–5.

Ogle, J.P., Park, J., Damhorst, M.L. and Bradley, L.A., 2016. Social Support for Women Who Have Undergone Bariatric Surgery. *Qualitative Health Research,* 26(2), pp.176–93.

Oliveira, A.J., Rostila, M., de Leon, A.P. and Lopes, C.S., 2013. The influence of social relationships on obesity: sex differences in a longitudinal study. *Obesity*, 21(8), pp.1540–7.

Olszewski, P.K., Klockars, A. and Levine, A.S., 2016. Oxytocin: a conditional anorexigen whose effects on appetite depend on the physiological, behavioural and social contexts. *Journal of Neuroendocrinology*, 28(4).

Oman, D., Thoresen, C.E. and Mcmahon, K., 1999. Volunteerism and mortality among the community-dwelling elderly. *Journal of Health Psychology,* 4(3), pp.301–316.

van Oostrom, M.A., Tijhuis, M.A., de Haes, J.C., Tempelaar, R. and Kromhout, D., 1995. A measurement of social support in epidemiological research: the social experiences checklist tested in a general population in The Netherlands. *Journal of Epidemiology & Community Health*, 49(5), pp.518–24.

Ortega, E., Morínigo, R., Flores, L., Moize, V., Rios, M., Lacy, A.M. and Vidal, J., 2012. Predictive factors of excess body weight loss 1 year after laparoscopic bariatric surgery. *Surgical Endoscopy*, 26(6), pp.1744–50.

Ortega, F.B., Brown, W.J., Lee, D., Baruth, M., Sui, X. and Blair, S.N., 2011. In fitness and health? A prospective study of changes in marital status and fitness in men and women. *American Journal of Epidemiology*, 173(3), pp.337–44.

Orth-Gomér, K., Rosengren, A. and Wilhelmsen, L., 1993. Lack of social support and incidence of coronary heart disease in middle-aged Swedish men. *Psychosomatic Medicine*, 55(1), pp.37–43.

Orth, W.S., Madan, A.K., Taddeucci, R.J., Coday, M. and Tichansky, D.S., 2008. Support group meeting attendance is associated with better weight loss. *Obesity Surgery*, 18(4), pp.391–4.

Ostbye, T., Malhotra, R. and Landerman, L.R., 2011. Body mass trajectories through adulthood: results from the National Longitudinal Survey of Youth 1979 Cohort (1981-2006). *International Journal of Epidemiology*, 40(1), pp.240–50.

Pachucki, M.C. and Goodman, E., 2015. Social Relationships and Obesity: Benefits of Incorporating a Lifecourse Perspective. *Current Obesity Reports*, 4(2), pp.217–23.

Palmisano, S., Silvestri, M., Giuricin, M., Baldini, E., Albertario, S., Capelli, P., Marzano, B., Fanti, G., Zompicchiatti, A., Millo, P., Fabozzi, M., Brachet Contul, R., Contul, R.B., Ponte, E., Allieta, R. and de Manzini, N., 2015. Preoperative Predictive Factors of Successful Weight Loss and Glycaemic Control 1 Year After Gastric Bypass for Morbid Obesity. *Obesity Surgery*, 25(11), pp.2040–6.

Patel, S.R. and Hu, F.B., 2008. Short Sleep Duration and Weight Gain: A Systematic Review. *Obesity*, 16(3), pp.643–653.

Pearlin, L.I. and Schooler, C., 1978. The structure of coping. *Journal of Health and Social Behavior*, 19(1), pp.2–21.

Picot, J., Jones, J., Colquitt, J.L., Gospodarevskaya, E., Loveman, E., Baxter, L. and Clegg, A.J., 2009. The clinical effectiveness and cost-effectiveness of bariatric (weight loss) surgery for obesity: a systematic review and economic evaluation. *Health Technology Assessment*, 13(41), pp.1–190.

Piferi, R.L. and Lawler, K.A., 2006. Social support and ambulatory blood pressure: an examination of both receiving and giving. *International Journal of Psychophysiology*, 62(2), pp.328–36.

Pinquart, M. and Sörensen, S., 2000. Influences of socioeconomic status, social network, and competence on subjective well-being in later life: a meta-analysis. *Psychology and Aging*, 15(2), pp.187–224.

Pischon, T., Boeing, H., Hoffmann, K., Bergmann, M., Schulze, M.B., Overvad, K., van der Schouw, Y.T., Spencer, E., Moons, K.G.M., et al., 2008. General and abdominal adiposity and risk of death in Europe. *The New England Journal of Medicine*, 359(20), pp.2105–20.

Poortinga, W., 2006. Do health behaviors mediate the association between social capital and health? *Preventive Medicine*, 43(6), pp.488–493.

Poulin, M.J., Brown, S.L., Dillard, A.J. and Smith, D.M., 2013. Giving to others and the association between stress and mortality. *American Journal of Public Health*, 103(9), pp.1649–55.

Poulin, M.J., Brown, S.L., Ubel, P.A., Smith, D.M., Jankovic, A. and Langa, K.M., 2010. Does a helping hand mean a heavy heart? Helping behavior and well-being among spouse caregivers. *Psychology and Aging*, 25(1), pp.108–117.

Powell, K., Wilcox, J., Clonan, A., Bissell, P., Preston, L., Peacock, M. and Holdsworth, M., 2015. The role of social networks in the development of overweight and obesity among adults: a scoping review. *BMC Public Health*, 15(1), p.996.

Power, M.J., Champion, L.A. and Aris, S.J., 1988. The development of a measure of social support: the Significant Others (SOS) Scale. *The British Journal of Clinical Psychology*, 27(1988), pp.349–58.

Puhl, R.M. and Brownell, K.D., 2006. Confronting and coping with weight stigma: an investigation of overweight and obese adults. *Obesity*, 14(10), pp.1802–15.

Puhl, R.M. and Heuer, C.A., 2009. The stigma of obesity: a review and update. *Obesity*, 17(5), pp.941–64.

Räikkönen, K., Matthews, K.A. and Kuller, L.H., 1999. Anthropometric and psychosocial determinants of visceral obesity in healthy postmenopausal women. *International Journal of Obesity and Related Metabolic Disorders*, 23(8), pp.775–82.

Rand, C.S., Kuldau, J.M. and Robbins, L., 1982. Surgery for obesity and marriage quality. *JAMA*, 247(10), pp.1419–22.

Rapp, I. and Schneider, B., 2013. The impacts of marriage, cohabitation and dating relationships on weekly self-reported physical activity in Germany: a 19-year longitudinal study. *Social Science & Medicine*, 98, pp.197–203.

Raspopow, K., Matheson, K., Abizaid, A. and Anisman, H., 2013. Unsupportive social interactions influence emotional eating behaviors. The role of coping styles as mediators. *Appetite*, 62(2013), pp.143–149.

Ravaja, N., Keltikangas-Järvinen, L. and Viikari, J., 1998. Perceived social support and abdominal fat distribution in adolescents and young adults: a structural equation analysis of prospective data. *Appetite*, 31(1), pp.21–35.

Ray, E.C., Nickels, M.W., Sayeed, S. and Sax, H.C., 2003. Predicting success after gastric bypass: the role of psychosocial and behavioral factors. *Surgery*, 134(4), pp.555–563.

Reblin, M. and Uchino, B.N., 2008. Social and emotional support and its implication for health. *Current Opinion in Psychiatry*, 21(2), pp.201–5.

Redd, M. and de Castro, J.M., 1992. Social facilitation of eating: Effects of social instruction on food intake. *Physiology & Behavior*, 52(4), pp.749–754.

Reevy, G.M. and Maslach, C., 2001. Use of Social Support: Gender and Personality Differences. *Sex Roles*, 44(7/8), pp.437–459.

Reis, H.T. and Gable, S.L., 2015. Responsiveness. *Current Opinion in Psychology*, 1(2015), pp.67–71.

Robinson, A.H., Adler, S., Stevens, H.B., Darcy, A.M., Morton, J.M. and Safer, D.L., 2014. What variables are associated with successful weight loss outcomes for bariatric surgery after 1 year? *Surgery for Obesity and Related Diseases*, 10(4), pp.697–704.

Robles, T.F. and Kiecolt-Glaser, J.K., 2003. The physiology of marriage: pathways to health. *Physiology & Behavior*, 79(3), pp.409–416.

Robles, T.F., Slatcher, R.B., Trombello, J.M. and McGinn, M.M., 2014. Marital quality and health: A meta-analytic review. *Psychological Bulletin*, 140(1), pp.140–187.

Roepke, S.K. and Grant, I., 2011. Toward a more complete understanding of the effects of personal mastery on cardiometabolic health. *Health Psychology*, 30(5), pp.615–32.

Rogers, R.G., 1995. Marriage, Sex, and Mortality. *Journal of Marriage and Family*, 57(2), pp.515–526.

Romo, L.K. and Dailey, R.M., 2014. Weighty dynamics: exploring couples' perceptions of post-weight-loss interaction. *Health Communication*, 29(2), pp.193–204.

Rook, K.S., 1984. The negative side of social interaction: impact on psychological well-being. *Journal of Personality and Social Psychology*, 46(5), pp.1097–1108.

Rook, K.S., Luong, G., Sorkin, D.H., Newsom, J.T. and Krause, N., 2012. Ambivalent versus problematic social ties: implications for psychological health, functional health, and interpersonal coping. *Psychology and Aging*, 27(4), pp.912–23.

le Roux, C.W., Aylwin, S.J.B., Batterham, R.L., Borg, C.M., Coyle, F., Prasad, V., Shurey, S., Ghatei, M.A., Patel, A.G. and Bloom, S.R., 2006. Gut hormone profiles following bariatric surgery favor an anorectic state, facilitate weight loss, and improve metabolic parameters. *Annals of Surgery*, 243(1), pp.108–14.

Rutledge, T., Adler, S. and Friedman, R., 2011. A prospective assessment of psychosocial factors among bariatric versus non-bariatric surgery candidates. *Obesity Surgery*, 21(10), pp.1570–9.

Sabia, S., Dugravot, A., Kivimaki, M., Brunner, E., Shipley, M.J. and Singh-Manoux, A., 2012. Effect of intensity and type of physical activity on mortality: results from the Whitehall II cohort study. *American Journal of Public Health*, 102(4), pp.698–704.

Salvy, S.-J., Jarrin, D., Paluch, R., Irfan, N. and Pliner, P., 2007. Effects of social influence on eating in couples, friends and strangers. *Appetite*, 49(1), pp.92–9.

Samter, W., 2002. How gender and cognitive complexity influence the provision of emotional support: A study of indirect effects. *Communication Reports*, 15(1), pp.5–16.

Sarason, I.G., Levine, H.M., Basham, R.B. and Sarason, B.R., 1983. Assessing Social Support : The Social Support Questionnaire. *Journal of Personality and Social Psychology*, 44(1), pp.127–139.

Sarason, I.G., Sarason, B.R., Shearin, E.N., Levine, H.M., Ruud, T., Watson, S., Cartwright, A., Burre, D., Hol, L., Hunter, G., Keefe, D., Mckinney, D. and Turteltaub, J., 1986. Social Support as an Individual Difference Variable: Its Stability, Origins, and Relational Aspects. *Journal of Personality and Social Psychology*, 50(4), pp.845–855.

Sassler, S., 2010. Partnering Across the Life Course: Sex, Relationships, and Mate Selection. *Journal of Marriage and Family*, 72(3), pp.557–575.

Scantlebury, R. and Moody, A., 2014. *Adult obesity and overweight*. *Health Survey for England*. London: The Health and Social care Information Centre. Available from: http://content.digital.nhs.uk/catalogue/PUB19295/HSE2014-ch9-adult-obe.pdf.

Schaefer, C., Coyne, J.C. and Lazarus, R.S., 1981. The health-related functions of social support. *Journal of Behavioral Medicine*, 4(4), pp.381–406.

Schauer, P.R., Ikramuddin, S., Gourash, W., Ramanathan, R. and Luketich, J., 2000. Outcomes after laparoscopic Roux-en-Y gastric bypass for morbid obesity. *Annals of Surgery,* 232(4), pp.515–29.

Schilling, R.F., 1987. Limitations of Social Support. *Social Service Review,* 61(1), pp.19–31.

Schlecker, M., 2013. Introduction. In: M., Schlecker and F., Fleischer, eds., *Ethnographies of Social Support*. New York: Palgrave Macmillan.

Schmitt, D.P. and Allik, J., 2005. Simultaneous administration of the Rosenberg Self-Esteem Scale in 53 nations: exploring the universal and culture-specific features of global self-esteem. *Journal of Personality and Social Psychology*, 89(4), pp.623–42.

Schneider, B. and Grimps, F., 2013. Role of National Divorce Rates in Moderating the Association Between Marriage Duration and Body Mass Index. *Marriage & Family Review*, 49(7), pp.606–622.

Schubert, M.I., Porkess, M. V, Dashdorj, N., Fone, K.C.F. and Auer, D.P., 2009. Effects of social isolation rearing on the limbic brain: a combined behavioral and magnetic resonance imaging volumetry study in rats. *Neuroscience*, 159(1), pp.21–30.

Schuster, T.L., Kessler, R.C. and Aseltine, R.H., 1990. Supportive interactions, negative interactions, and depressed mood. *American Journal of Community Psychology,* 18(3), pp.423–438.

Schwartz, C.E., Keyl, P.M., Marcum, J.P. and Bode, R., 2009. Helping Others Shows Differential Benefits on Health and Well-being for Male and Female Teens. *Journal of Happiness Studies*, 10(4), pp.431–448.

Schwartz, C.E. and Sendor, R.M., 1999. Helping others helps oneself: response shift effects in peer support. *Social Science & Medicine*, 48(11), pp.1563–1575.

Schwarzer, R. and Leppin, A., 1989. Social support and health: A meta-analysis. *Psychology & Health,* 3(1), pp.1–15.

Science and Technology Committee. Eleventh Report: *Alcohol Guidelines*. 2011. House of Commons (December 2011). Available from: https://publications.parliament.uk/pa/cm201012/cmselect/cmsctech/1536/1536.pdf.

Scott, K.M., McGee, M.A., Wells, J.E. and Oakley Browne, M.A., 2008. Obesity and mental disorders in the adult general population. *Journal of Psychosomatic Research*, 64(1), pp.97–105.

Scozzari, G., Passera, R., Benvenga, R., Toppino, M. and Morino, M., 2012. Age as a long-term prognostic factor in bariatric surgery. *Annals of Surgery*, 256(5), pp.724-8-9.

Seeman, T.E., Lusignolo, T.M., Albert, M. and Berkman, L., 2001. Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. *Health Psychology,* 20(4), pp.243–55.

Seidell, J.C., 2010. Waist circumference and waist/hip ratio in relation to all-cause mortality, cancer and sleep apnea. *European Journal of Clinical Nutrition*, 64(1), pp.35–41.

Selcuk, E. and Ong, A.D., 2013. Perceived partner responsiveness moderates the association between received emotional support and all-cause mortality. *Health Psychology*, 32(2), pp.231–235.

Shankar, A., McMunn, A., Banks, J. and Steptoe, A., 2011. Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychology*, 30(4), pp.377–85.

Shaw, B.A., Krause, N., Liang, J. and Bennett, J., 2007. Tracking changes in social relations throughout late life. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 62(2), pp.S90-9.

Sheets, C.S., Peat, C.M., Berg, K.C., White, E.K., Bocchieri-Ricciardi, L., Chen, E.Y. and Mitchell, J.E., 2015. Post-operative psychosocial predictors of outcome in bariatric surgery. *Obesity Surgery*, 25(2), pp.330–45.

Sherbourne, C.D. and Stewart, A.L., 1991. The MOS social support survey. *Social Science & Medicine*, 32(6), pp.705–714.

Shiri, S., Gurevich, T., Feintuch, U. and Beglaibter, N., 2007. Positive psychological impact of bariatric surgery. *Obesity Surgery*, 17(5), pp.663–8.

Shor, E., Roelfs, D.J., Bugyi, P. and Schwartz, J.E., 2012. Meta-analysis of marital dissolution and mortality: re-evaluating the intersection of gender and age. *Social Science & Medicine*, 75(1), pp.46–59.

Shumaker, S.A. and Brownell, A., 1984. Toward a Theory of Social Support: Closing Conceptual Gaps. *Journal of Social Issues*, 40(4), pp.11–36.

Singh, G., Danaei, G., Farzadfar, F., et al., 2016. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *The Lancet*, 387(10026), pp.1377–1396.

Sjöström, L., Lindroos, A.-K., Peltonen, M., Torgerson, J., Bouchard, C., Carlsson, B., Dahlgren, S., Larsson, B., Narbro, K., Sjöström, C.D., Sullivan, M. and Wedel, H., 2004. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *The New England Journal of Medicine*, 351(26), pp.2683–93.

Slatcher, R.B. and Schoebi, D., 2017. Protective processes underlying the links between marital quality and physical health. *Current Opinion in Psychology*, 13, pp.148–152.

Slatcher, R.B., Selcuk, E. and Ong, A.D., 2015. Perceived Partner Responsiveness Predicts Diurnal Cortisol Profiles 10 Years Later. *Psychological Science,* 26(7), pp.972–82.

Sneed, R.S. and Cohen, S., 2013. A prospective study of volunteerism and hypertension risk in older adults. *Psychology and Aging*, 28(2), pp.578–586.

Snijder, M.B., van Dam, R.M., Visser, M. and Seidell, J.C., 2006. What aspects of body fat are particularly hazardous and how do we measure them? *International Journal of Epidemiology*, 35(1), pp.83–92.

Snyder, B., Nguyen, A., Scarbourough, T., Yu, S. and Wilson, E., 2009. Comparison of those who succeed in losing significant excessive weight after bariatric surgery and those who fail. *Surgical Endoscopy*, 23(10), pp.2302–6.

Sobal, J., 2005. Social consequences of weight bias by partners, friends, and strangers. In: K.D., Brownell, R.M., Puhl, M.B., Schwartz and L., Rudd, eds., *Weight bias: Nature, Consequences, and Remedies*. New York: The Guilford Press, pp.150–164.

Sobal, J. and Hanson, K.L., 2011. Marital Status, Marital History, Body Weight, and Obesity. *Marriage & Family Review*, 47(7), pp.474–504.

Sobal, J. and Nelson, M.K., 2003. Commensal eating patterns: a community study. *Appetite*, 41(2), pp.181–190.

Sobal, J., Rauschenbach, B. and Frongillo, E.A., 2003. Marital status changes and body weight changes: a US longitudinal analysis. *Social Science & Medicine*, 56(7), pp.1543–1555.

Sobal, J., Rauschenbach, B.S. and Frongillo, E.A., 1992. Marital status, fatness and obesity. *Social Science & Medicine*, 35(7), pp.915–923.

Sobal, J., Rauschenbach, B.S. and Frongillo, E.A., 1995. Obesity and Marital Quality: Analysis of Weight, Marital Unhappiness, and Marital Problems in a U.S. National Sample. *Journal of Family Issues*, 16(6), pp.746–764.

Song, Z., Reinhardt, K., Buzdon, M. and Liao, P., 2008. Association between support group attendance and weight loss after Roux-en-Y gastric bypass. *Surgery for Obesity and Related Diseases*, 4(2), pp.100–3.

Spitze, G. and Gallant, M.P., 2004. 'The Bitter With the Sweet': Older Adults' Strategies for Handling Ambivalence in Relations With Their Adult Children. *Research on Aging*, 26(4), pp.387–412.

Stafford, M., Bendayan, R., Tymoszuk, U. and Kuh, D., 2017. Social support from the closest person and sleep quality in later life: Evidence from a British birth cohort study. *Journal of Psychosomatic Research,* 98, pp.1–9.

Stafford, M., McMunn, A., Zaninotto, P. and Nazroo, J., 2011. Positive and negative exchanges in social relationships as predictors of depression: evidence from the English Longitudinal Study of Aging. *Journal of Aging and Health*, 23(4), pp.607–28.

Stansfeld, S.A., Fuhrer, R. and Shipley, M.J., 1998. Types of social support as predictors of psychiatric morbidity in a cohort of British Civil Servants (Whitehall II Study). *Psychological Medicine*, 28(4), pp.881–892.

Stansfeld, S. and Marmot, M., 1992. Deriving a survey measure of social support: The reliability and validity of the close persons questionnaire. *Social Science & Medicine*, 35(8), pp.1027–1035.

Stenholm, S., Vahtera, J., Kawachi, I., Pentti, J., Halonen, J.I., Westerlund, H., Razak, F., Subramanian, S. V and Kivimäki, M., 2015. Patterns of weight gain in middle-aged and older US adults, 1992-2010. *Epidemiology*, 26(2), pp.165–8.

Stetler, C.A. and Miller, G.E., 2008. Social integration of daily activities and cortisol secretion: a laboratory based manipulation. *Journal of Behavioral Medicine*, 31(3), pp.249–257.

Switzer, N.J., Merani, S., Skubleny, D., Pelletier, J.-S., Kanji, R., Shi, X., Birch, D.W., de Gara, C., Sharma, A.M., Gill, R.S. and Karmali, S., 2016. Quality of Follow-up: Systematic Review of the Research in Bariatric Surgery. *Annals of Surgery*, 263(5), pp.875–80.

Tamers, S.L., Okechukwu, C., Allen, J., Yang, M., Stoddard, A., Tucker-Seeley, R. and Sorensen, G., 2013. Are social relationships a healthy influence on obesogenic behaviors among racially/ethnically diverse and socio-economically disadvantaged residents? *Preventive Medicine*, 56(1), pp.70–4.

Tamres, L.K., Janicki, D. and Helgeson, V.S., 2002. Sex Differences in Coping Behavior: A Meta-Analytic Review and an Examination of Relative Coping. *Personality and Social Psychology Review*, 6(1), pp.2–30.

Taylor, R.W., Roy, M., Jospe, M.R., Osborne, H.R., Meredith-Jones, K.J., Williams, S.M., Brown, R.C., et al., 2015. Determining how best to support overweight adults to adhere to lifestyle change: protocol for the SWIFT study. *BMC Public Health*, 15(1), p.861.

Taylor, S.E., 2007. Social Support. In: H.S. Friedman and R.C. Silver, eds., *Foundations of Health Psychology*. New York: Oxford University Press.

Teachman, J., 2016. Body Weight, Marital Status, and Changes in Marital Status. *Journal of Family Issues*, 37(1), pp.74–96.

The, N.S. and Gordon-Larsen, P., 2009. Entry into romantic partnership is associated with obesity. *Obesity*, 17(7), pp.1441–7.

Thoits, P.A., 2011. Mechanisms Linking Social Ties and Support to Physical and Mental Health. *Journal of Health and Social Behavior*, 52(2), pp.145–61.

Thomas, P.A., 2010. Is it better to give or to receive? Social support and the well-being of older adults. *The Journals of Gerontology. Series B, Psychological Sciences And Social* sciences, 65B(3), pp.351–7.

Thonney, B., Pataky, Z., Badel, S., Bobbioni-Harsch, E. and Golay, A., 2010. The relationship between weight loss and psychosocial functioning among bariatric surgery patients. *The American Journal of Surgery*, 199(2), pp.183–188.

Tsai, A.G. and Wadden, T.A., 2005. Systematic review: an evaluation of major commercial weight loss programs in the United States. *Annals of Internal Medicine*, 142(1), pp.56–66.

Tucker, J. and Anders, S.L., 2001. Social Control of Health Behaviors in Marriage. *Journal of Applied Social Psychology*, 31(3), pp.467–485.

Uchino, B.N., 2006. Social support and health: a review of physiological processes potentially underlying links to disease outcomes. *Journal of Behavioral Medicine*, 29(4), pp.377–387.

Uchino, B.N., 2009. Understanding the Links Between Social Support and Physical Health: A Life-Span Perspective With Emphasis on the Separability of Perceived and Received Support. *Perspectives on Psychological Science*, 4(3), pp.236–55.

Uchino, B.N., Bowen, K., Carlisle, M. and Birmingham, W., 2012. Psychological pathways linking social support to health outcomes: a visit with the 'ghosts' of research past, present, and future. *Social Science & Medicine*, 74(7), pp.949–57.

Uchino, B.N., Holt-Lunstad, J., Uno, D. and Flinders, J.B., 2001. Heterogeneity in the social networks of young and older adults: prediction of mental health and cardiovascular reactivity during acute stress. *Journal of Behavioral Medicine*, 24(4), pp.361–382.

Umberson, D., 1992. Gender, marital status and the social control of health behavior. *Social Science & Medicine*, 34(8), pp.907–917.

Umberson, D., Crosnoe, R. and Reczek, C., 2010. Social Relationships and Health Behavior Across Life Course. *Annual Review of Sociology*, 36, pp.139–157.

Umberson, D., Liu, H. and Powers, D., 2009. Marital status, marital transitions, and body weight. *Journal of Health and Social Behavior*, 50(3), pp.327–43.

Vazquez, G., Duval, S., Jacobs, D.R. and Silventoinen, K., 2007. Comparison of body mass index, waist circumference, and waist/hip ratio in predicting incident diabetes: a meta-analysis. *Epidemiologic Reviews*, 29(1), pp.115–28.

Verheijden, M.W., Bakx, J.C., van Weel, C., Koelen, M.A. and van Staveren, W.A., 2005. Role of social support in lifestyle-focused weight management interventions. *European Journal of Clinical Nutrition*, 59(Suppl 1), pp.S179–S186.

Vishne, T.H., Ramadan, E., Alper, D., Avraham, Z., Seror, D. and Dreznik, Z., 2004. Long-term follow-up and factors influencing success of silastic ring vertical gastroplasty. *Digestive Surgery*, 21(2), pp.134-40–1.

De Vogli, R., Chandola, T. and Marmot, M.G., 2007. Negative aspects of close relationships and heart disease. *Archives of Internal Medicine*, 167(18), pp.1951–1957.

Wadden, T.A., Sarwer, D.B., Fabricatore, A.N., Jones, L., Stack, R. and Williams, N.S., 2007. Psychosocial and behavioral status of patients undergoing bariatric surgery: what to expect before and after surgery. *The Medical Clinics of North America*, 91(3), pp.451–69.

Waite, L.J., 1995. Does Marriage Matter? *Demography*, 32(4), p.483.

Walen, H.R. and Lachman, M.E., 2000. Social Support and Strain from Partner, Family, and Friends: Costs and Benefits for Men and Women in Adulthood. *Journal of Social and Personal Relationships*, 17(1), pp.5–30.

Walsemann, K.M. and Ailshire, J.A., 2011. BMI Trajectories During the Transition to Older Adulthood: Persistent, Widening, or Diminishing Disparities by Ethnicity and Education? *Research on Aging*, 33(3), pp.286–311.

Wannamethee, S.G., Shaper, A.G. and Lennon, L., 2005. Reasons for intentional weight loss, unintentional weight loss, and mortality in older men. *Archives of Internal Medicine*, 165(9), pp.1035–40.

Warner, L.M., Schüz, B., Wurm, S., Ziegelmann, J.P. and Tesch-Römer, C., 2010. Giving and taking--differential effects of providing, receiving and anticipating emotional support on quality of life in adults with multiple illnesses. *Journal of Health Psychology*, 15(5), pp.660–70.

Wedin, S., Madan, A., Correll, J., Crowley, N., Malcolm, R., Karl Byrne, T. and Borckardt, J.J., 2014. Emotional eating, marital status and history of physical abuse predict 2-year weight loss in weight loss surgery patients. *Eating Behaviors*, 15(4), pp.619–624.

Welch, C., Petersen, I., Walters, K., Morris, R.W., Nazareth, I., Kalaitzaki, E., White, I.R., Marston, L. and Carpenter, J., 2012. Two-stage method to remove population- and individual-level outliers from longitudinal data in a primary care database. *Pharmacoepidemiology and Drug Safety*, 21(7), pp.725–732.

Whisman, M.A., 2010. Loneliness and the metabolic syndrome in a population-based sample of middle-aged and older adults. *Health Psychology*, 29(5), pp.550–4.

White, I.R., Royston, P. and Wood, A.M., 2011. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine*, 30(4), pp.377–99.

Williams, K. and Umberson, D., 2004. Marital status, marital transitions, and health: a gendered life course perspective. *Journal of Health and Social Behavior*, 45(1), pp.81–98.

Wills, T.A. and Shinar, O., 2000. Measuring Perceived and Received Social Support. In: S. Cohen, L.G. Underwood and B.H. Gottlieb, eds., *Social Support Measurement and Intervention: A Guide for Health and Social Scientists*, 1st ed. New York: Oxford University Press, pp.86–135.

Wilson, S.E., 2012. Marriage, gender and obesity in later life. *Economics & Human Biology*, 10(4), pp.431–453.

Wing, R.R., Matthews, K.A., Kuller, L.H., Meilahn, E.N. and Plantinga, P., 1991. Waist to hip ratio in middle-aged women. Associations with behavioral and psychosocial factors and with changes in cardiovascular risk factors. *Arteriosclerosis, Thrombosis, and Vascular Biology*, 11(5), pp.1250–1257.

Wink, P. and Dillion, M., 2007. Do generative adolescents become healthy older adults. In: S.G., Post, ed., *Altruism and health: Perspectives from empirical research*, 1st ed. New York: Oxford University Press, pp.43–54.

de Wit, L., Luppino, F., van Straten, A., Penninx, B., Zitman, F. and Cuijpers, P., 2010. Depression and obesity: a meta-analysis of community-based studies. *Psychiatry Research,* 178(2), pp.230–5.

Wittig, R.M., Crockford, C., Deschner, T., Langergraber, K.E., Ziegler, T.E. and Zuberbühler, K., 2014. Food sharing is linked to urinary oxytocin levels and bonding in related and unrelated wild chimpanzees. *Proceedings of the Royal Society of London B: Biological Sciences*, 281(1778), pp.1-10.

Wolfe, B.M., Kvach, E. and Eckel, R.H., 2016. Treatment of Obesity: Weight Loss and Bariatric Surgery. *Circulation Research*, 118(11), pp.1844–55.

Woo, J., Ho, S.C. and Sham, A., 2001. Longitudinal changes in body mass index and body composition over 3 years and relationship to health outcomes in Hong Kong Chinese age 70 and older. *Journal of the American Geriatrics Society*, 49(6), pp.737–46.

Yan, L.L., Daviglus, M.L., Liu, K., Pirzada, A., Garside, D.B., Schiffer, L., Dyer, A.R. and Greenland, P., 2004. BMI and health-related quality of life in adults 65 years and older. *Obesity Research*, 12(1), pp.69–76.

Zajacova, A. and Ailshire, J., 2014. Body mass trajectories and mortality among older adults: a joint growth mixture-discrete-time survival analysis. *The Gerontologist*, 54(2), pp.221–31.

Zajacova, A., Huzurbazar, S., Greenwood, M. and Nguyen, H., 2015. Long-Term BMI Trajectories and Health in Older Adults: Hierarchical Clustering of Functional Curves. *Journal of Aging and Health*, 27(8), pp.1443–61.

Zaki, J. and Williams, W.C., 2013. Interpersonal emotion regulation. *Emotion*, 13(5), pp.803–810.

Zhang, C., Rexrode, K.M., van Dam, R.M., Li, T.Y. and Hu, F.B., 2008. Abdominal obesity and the risk of all-cause, cardiovascular, and cancer mortality: sixteen years of follow-up in US women. *Circulation*, 117(13), pp.1658–67.

Zhang, Q., Li, H. and Guo, F., 2011. Amygdala, an important regulator for food intake. *Frontiers in Biology*, 6(1), pp.82–85.

Zheng, H., Tumin, D. and Qian, Z., 2013. Obesity and Mortality Risk: New Findings From Body Mass Index Trajectories. *American Journal of Epidemiology*, 178(11), pp.1591–1599.

Appendices

Appendix I: Cross-sectional analysis of the imputed dataset

Table 37 Descriptive characteristics of participants included in the cross-sectional analysis using the imputed dataset, n=6,718

	Total
	%
Gender	
Men	69.7
Women	30.2
Age [mean (95% confidence interval)]	47.70 (47.55-47.84)
BMI [mean (95% confidence interval)]	25.29 (25.20-25.37)
WHR: men [mean (95% confidence interval)]	0.902 (0.901-0.904)
WHR: women [mean (95% confidence interval)]	0.774 (0.771-0.777)
Ethnicity	
White British	91.7
South Asian	4.5
Black African & Caribbean	2.7
Other	0.7
Longstanding illness	
Yes	35.8
No	64.2
Employment grade	
Administrative	36.4
Professional/Executive	47.6
Clerical/support	16.0
Smoking status	
Never-smoker	50.4
Ex-smoker	36.0
Current smoker	13.6
Freq. of fruit & veg intake	
Less than daily	40.5
Daily and more	59.5
Freq. of mild exercise	
>3/week	67.5
1-2/week	24.8
1-3/month & seldom	7.7
Freq. of moderate exercise	

>3/week	13.6
1-2/week	41.6
1-3/month	32.3
Seldom	12.5
Freq. of vigorous exercise	
1-3/week	20.6
1-3/month	19.2
Seldom	60.2
GHQ score	
< 4	70.0
≥ 5	30.2
Alcohol intake*	
Low <14/21 units	85.1
High >14/21 units	14.9
Emotional support	
Tertile 1 (low)	34.7
Tertile 2	35.1
Tertile 3 (high)	30.3
Practical support	
Tertile 1 (low)	37.1
Tertile 2	35.0
Tertile 3 (high)	27.8
Negative interactions	
Tertile (low)	36.0
Tertile 2	35.3
Tertile 3 (high)	28.7
Relationship status	
Married/cohabiting	76.6
Single	14.9
Divorced	7.3
Widowed	1.3

*Recommended maximum alcohol intake per week for men: 21 units and for women: 14 units

Table 38 Multiply adjusted associations between support and BMI in the imputed dataset, n=6,718. All exposures (social support variables and marital status) were entered in separate models.

		BMI (kg/m^2)			
	n	Model 1 coefficient (SE) **+ age & gender**	Model 2 coefficient (SE) **+ grade & ethnicity**	Model 3 coefficient (SE) **+ health behav.**	Model 4 coefficient (SE) **+ GHQ**
Emotional support					
Tertile 1 (low)	2,330	-0.22 (0.11)*	-0.25 (0.11)*	-0.30 (0.11)**	-0.30 (0.11)**
Tertile 2	2,355	-0.10 (0.11)	-0.11 (0.11)	-0.11 (0.11)	-0.11 (0.11)
Tertile 3	2,033	Reference	reference	reference	reference
Practical support					
Tertile 1 (low)	2,491	-0.43 (0.11)†	-0.45 (0.11)†	-0.55 (0.11)†	-0.54 (0.11)†
Tertile 2	2,357	-0.38 (0.11)**	-0.36 (0.11)**	-0.40 (0.11)†	-0.39 (0.11)†
Tertile 3	1,870	Reference	reference	reference	reference
Negative aspects					
Tertile 1 (low)	2,417	-0.22 (0.11)*	-0.20 (0.11)	-0.14 (0.11)	-0.14 (0.11)
Tertile 2	2,371	-0.32 (0.11)**	-0.31 (0.11)**	-0.29 (0.11)*	-0.28 (0.11)*
Tertile 3	1,930	reference	reference	reference	reference
Relationship status					
Married/cohabiting	5,143	reference	reference	reference	reference
Single	998	-0.26 (0.13)*	-0.31 (0.13)*	-0.33 (0.13)*	-0.33 (0.13)*
Divorced/widowed	577	+0.42 (0.36)*	+0.27 (0.16)	+0.20 (0.16)	+0.19 (0.16)

* p<0.05; ** p<0.01, † p<0.001; Model 1: adjusted for gender, age; Model 2: Model 1 + employment grade and ethnicity (+ long standing illness in model with practical support); Model 3: Model 2 + health behaviours: smoking; alcohol consumption (units/wk.); fruit and vegetable consumption; mild, moderate and vigorous physical activity frequency; Model 4: Model 3 + GHQ (all covariates)

Table 39 Multiply adjusted associations between social support and WHR in the imputed dataset, n=6,718. All exposures (social support variables and marital status) were entered in separate models.

		WHR			
	n	Model 1 coefficient (SE) **+ age & gender**	Model 2 coefficient (SE) **+ grade & ethnicity**	Model 3 coefficient (SE) **+ health behav.**	Model 4 coefficient (SE) **+ GHQ**
Emotional support					
Tertile 1	2,330	-0.003 (0.002)	-0.003 (0.002)	-0.004 (0.002)*	-0.005 (0.002)*
Tertile 2	2,355	-0.002 (0.002)	-0.003 (0.002)	-0.003 (0.002)	-0.003 (0.002)
Tertile 3	2,033	reference	reference	reference	reference
Practical support					
Tertile 1	2,491	-0.006 (0.002)**	-0.006 (0.002)**	-0.008 (0.002)†	-0.008 (0.002)†
Tertile 2	2,357	-0.003 (0.002)	-0.002 (0.002)	-0.003 (0.002)	-0.003 (0.002)
Tertile 3	1,870	reference	reference	reference	reference
Negative aspects					
Tertile 1	2,417	-0.007 (0.002)†	-0.004 (0.002)*	-0.002 (0.002)	-0.002 (0.002)
Tertile 2	2,371	-0.008 (0.002)†	-0.005 (0.002)**	-0.004 (0.002)*	-0.004 (0.002)*
Tertile 3	1,930	reference	reference	reference	reference
Relationship status					
Married/cohabiting	5,143	reference	reference	reference	reference
Single	998	-0.006 (0.002)*	-0.006 (0.002)**	-0.006 (0.002)**	-0.006 (0.002)**
Divorced/widowed	577	+0.007 (0.003)*	+0.005 (0.003)	+0.003 (0.003)	+0.003 (0.003)

* p<0.05; ** p<0.01, † p<0.001; Model 1: adjusted for gender, age; Model 2: Model 1 + employment grade and ethnicity (+ long standing illness in model with practical support); Model 3: Model 2 + health behaviours: smoking; alcohol consumption (units/wk.); fruit and vegetable consumption; mild, moderate and vigorous physical activity frequency; Model 4: Model 3 + GHQ (all covariates)

Appendix II: Characteristics of participants included in the longitudinal analysis (non-imputed data)

Table 40 Characteristics of participants included in the longitudinal analysis (complete case analysis, n=5,773). All variables were collected at phase 2 (1989-1990).

	Total	**Men**	**Women**
	N (%)	**N (%)**	**N (%)**
Gender	----	4,118 (71.3)	1,655 (28.7)
Age [**mean (95% CI)]**	47.37 (47.22-47.52)	47.20 (47.02-47.38)	47.79 (47.50-48.02)†
Employment grade			
Administrative **(ref)**	2,244 (38.9)	1,955 (47.5)	289 (17.5)
Professional/executive	2,772 (48.0)	1,956 (47.5)	816 (49.3)†
Clerical/support	757 (13.1)	207 (5.0)	550 (33.2)†
Ethnicity			
White British **(ref)**	5,388 (93.3)	3,896 (94.6)	1,492 (90.2)
South Asian	234 (4.1)	159 (3.9)	75 (4.5)
Black African & Caribbean	113 (2.0)	47 (1.1)	66 (4.0)†
Other	38 (0.6)	16 (0.4)	22 (1.3)†
Longstanding illness			
Yes **(ref)**	2,042 (35.4)	1,435 (34.8)	607 (36.7)
No	3,731 (64.6)	2,683 (65.2)	1,048 (63.3)
Smoking status			
Never-smoker **(ref)**	2,965 (51.4)	2,031 (49.4)	934 (56.4)
Ex-smoker	2,084 (36.1)	1,624 (39.4)	460 (27.8)†
Current smoker	724 (12.5)	463 (11.2)	261 (15.8)*
Freq. of fruit & veg intake			
Less than daily **(ref)**	2,282 (39.5)	1,729 (42.0)	553 (33.4)
Daily and more	3,491 (60.5)	2,389 (58.0)	1,102 (66.6)†
Freq. of mild exercise			
>3/week **(ref)**	3,911 (67.8)	2,871 (69.7)	1,040 (62.8)
1-2/week	1,412 (24.4)	941 (22.9)	471 (28.5)†
1-3/month	336 (5.8)	243 (5.9)	93 (5.6)
Seldom	114 (2.0)	63 (1.5)	51 (3.1)†
Freq. of moderate exercise			
>3/week **(ref)**	753 (13.0)	583 (14.2)	170 (10.3)
1-2/week	2,392 (41.4)	1,796 (43.6)	596 (36.0)
1-3/month	1,911 (33.1)	1,371 (33.3)	540 (32.6)**
Seldom	717 (12.4)	368 (8.9)	349 (21.1)†

Freq. of vigorous exercise			
>3/week **(ref)**	324 (5.6)	278 (6.8)	46 (2.8)
1-2/week	822 (14.2)	685 (16.6)	137 (8.3)
1-3/month	1,169 (20.3)	956 (23.2)	213 (12.9)
Seldom	3,458 (59.9)	2,199 (53.4)	1,259 (76.0)†
GHQ score			
< 4	4,027 (69.8)	2,963 (72.0)	1,064 (64.3)
≥ 5	1,746 (30.2)	1,115 (28.0)	591 (35.7)†
Alcohol intake*			
Low <14/21 units	4,887 (84.7)	3,386 (82.2)	1,501 (90.7)
High >14/21 units	886 (15.4)	732 (17.8)	154 (9.3)
Emotional support			
Tertile 1 (low)	2,004 (34.7)	1,471 (35.7)	533 (32.2)
Tertile 2	1,855 (32.1)	1,283 (31.2)	572 (34.6)
Tertile 3 (high, **ref**)	1,914 (33.2)	1,364 (33.1)	550 (33.2)
Practical support			
Tertile 1 (low)	2,147 (37.2)	1,367 (33.2)	780 (47.1)†
Tertile 2	2,033 (35.2)	1,476 (35.8)	557 (33.7)†
Tertile 3 (high, **ref**)	1,593 (27.6)	1,275 (31.0)	318 (19.2)
Negative interactions			
Tertile (low)	2,067 (35.8)	1,455 (35.3)	612 (37.0)
Tertile 2	2,070 (35.9)	1,498 (36.4)	572 (34.5)
Tertile 3 (high, **ref**)	1,636 (28.3)	1,165 (28.3)	471 (28.5)
Relationship status			
Married/cohabiting **(ref)**	4,477 (77.5)	3,468 (84.2)	1,009 (61.0)
Single	830 (14.4)	455 (11.1)	375 (22.7)†
Divorced/widowed	466 (8.1)	195 (4.7)	271 (16.4)†

Appendix III: Complete longitudinal analysis of the non-imputed data

Table 41 Trajectories of BMI by social support over phases 3 (1991-1994) – 11 (2012-2013), complete case analysis, n=5,773. All exposures (social support variables and relationship status) were entered in separate models.

	BMI: men, n=4,118			BMI: women, n=1,655		
Model	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient
M1: Emotional support						
Tertile 1 (low)	-0.147 (0.131)	+0.029 (0.012)*	-0.0011 (0.0004)*	-0.306 (0.318)	+0.042 (0.027)	-0.0015 (0.0010)
Tertile 2 (medium)	-0.104 (0.132)	+0.030 (0.012)*	-0.0010 (0.0004)*	-0.087 (0.306)	+0.065 (0.026)*	-0.0017 (0.0001)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M2: Emotional support						
Tertile 1 (low)	-0.168 (0.131)	+0.029 (0.012)*	-0.0011 (0.0004)*	-0.278 (0.298)	+0.042 (0.027)	-0.0015 (0.0010)
Tertile 2 (medium)	-0.111 (0.132)	+0.027 (0.012)*	-0.0010 (0.0004)*	-0.113 (0.288)	+0.065 (0.026)*	-0.0019 (0.0009)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M3: Emotional support						
Tertile 1 (low)	-0.245 (0.130)	+0.029 (0.012)*	-0.0011 (0.0004)*	-0.430 (0.312)	+0.042 (0.027)	-0.0015 (0.0010)
Tertile 2 (medium)	-0.132 (0.130)	+0.027 (0.012)*	-0.0011 (0.0004)*	-0.182 (0.300)	+0.065 (0.026)*	-0.0019 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Emotional support						
Tertile 1 (low)	-0.236 (0.130)	+0.029 (0.012)*	-0.0011 (0.0004)*	-0.434 (0.312)	+0.042 (0.027)	-0.0015 (0.0010)
Tertile 2 (medium)	-0.128 (0.130)	+0.027 (0.012)*	-0.0010 (0.0004)*	-0.188 (0.300)	+0.065 (0.026)*	-0.0019 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference

M1: Practical support						
Tertile 1 (low)	-0.039 (0.132)	-0.015 (0.011)	+0.0004 (0.0004)	-0.996 (0.339)**	-0.004 (0.029)	0.0002 (0.0011)
Tertile 2 (medium)	-0.017 (0.130)	0.002 (0.011)	-0.0005 (0.0004)	-1.186 (0.358)**	+0.033 (0.030)	-0.0012 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M2: Practical support						
Tertile 1 (low)	-0.074 (0.133)	-0.015 (0.012)	+0.0004 (0.0004)	-0.921 (0.336)**	-0.004 (0.029)	+0.0002 (0.0011)
Tertile 2 (medium)	-0.021 (0.130)	0.002 (0.011)	-0.0005 (0.0004)	-1.129 (0.353)**	+0.033 (0.029)	-0.0012 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M3: Practical support						
Tertile 1 (low)	-0.221 (0.131)	-0.015 (0.012)	+0.0004 (0.0004)	-1.023 (0.335)**	-0.003 (0.029)	+0.0002 (0.0011)
Tertile 2 (medium)	-0.071 (0.127)	0.003 (0.011)	-0.0005 (0.0004)	-1.142 (0.353)**	+0.030 (0.030)	-0.0012 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Practical support						
Tertile 1 (low)	-0.214 (0.131)	-0.015 (0.012)	+0.0004 (0.0004)	-0.987 (0.335)**	-0.003 (0.030)	+0.0002 (0.0011)
Tertile 2 (medium)	-0.068 (0.127)	0.002 (0.011)	-0.0005 (0.0004)	-1.148 (0.353)**	+0.031 (0.033)	-0.0012 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Negative aspects						
Tertile 1 (low)	-0.150 (0.133)	-0.030 (0.012)*	+0.0008 (0.0004)	-0.275 (0.315)	+0.021 (0.027)	-0.0005 (0.0010)
Tertile 2 (medium)	-0.341 (0.132)*	-0.015 (0.012)	+0.0005 (0.0004)	-0.436 (0.318)	+0.061 (0.027)*	-0.0018 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M2: Negative aspects						
Tertile 1 (low)	-0.160 (0.134)	-0.030 (0.012)*	+0.0008 (0.0004)	-0.279 (0.313)	+0.021 (0.027)	-0.0005 (0.0010)
Tertile 2 (medium)	-0.349 (0.133)**	-0.015 (0.012)	+0.0005 (0.0004)	-0.459 (0.315)	+0.060 (0.027)*	-0.0017 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference

M3: Negative aspects						
Tertile 1 (low)	-0.132 (0.132)	-0.030 (0.012)*	+0.0007 (0.0004)	-0.117 (0.312)	+0.021 (0.027)	-0.0005 (0.0010)
Tertile 2 (medium)	-0.335 (0.130)*	-0.016 (0.012)	+0.0005 (0.0004)	-0.465 (0.314)	+0.060 (0.027)*	-0.0018 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Negative aspects						
Tertile 1 (low)	-0.183 (0.135)	-0.030 (0.012)*	0.0008 (0.0004)	-0.070 (0.319)	+0.021 (0.026)	-0.0005 (0.0010)
Tertile 2 (medium)	-0.365 (0.132)**	-0.015 (0.012)	0.0006 (0.0004)	-0.444 (0.315)	+0.060 (0.027)*	-0.0018 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.296 (0.161)	+0.019 (0.006)**	----	-0.215 (0.295)	+0.013 (0.011)	----
Divorced/widowed	+0.454 (0.220)	+0.003 (0.009)	----	+0.423 (0.336)	+0.016 (0.012)	----
M2: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.406 (0.153)*	+0.019 (0.006)**	----	-0.147 (0.275)	+0.013 (0.011)	----
Divorced/widowed	+0.410 (0.220)	+0.003 (0.009)	----	+0.355 (0.331)	+0.016 (0.013)	----
M3: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.472 (0.163)**	+0.019 (0.006)**	----	-0.166 (0.294)	+0.013 (0.011)	----
Divorced/widowed	+0.218 (0.234)	+0.003 (0.009)	----	+0.263 (0.331)	+0.016 (0.013)	----
M4: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.466 (0.163)**	+0.019 (0.006)**	----	-0.165 (0.294)	+0.013 (0.011)	----
Divorced/widowed	+0.240 (0.235)	+0.003 (0.009)	----	+0.252 (0.331)	+0.016 (0.013)	----

* <0.05; ** p<0.01; **M1: unadjusted model**: age at baseline; **M2**: M1 + ethnicity + employment grade; **M3:** M2 + health behaviours, **M4**: all covariates in M3+ GHQ

Table 42 Trajectories of WHR by social support over phases 3 (1991-1994) – 11 (2012-2013), complete case analysis, n=5,773. All exposures (social support variables and relationship status) were entered in separate models.

	WHR: men, n=4,118		**WHR: women, n=1,655**	
Model	Intercept coefficient	Linear slope coefficient	Intercept coefficient	Linear slope coefficient
M1: Emotional support				
Tertile 1 (low)	+0.0003 (0.0024)	+0.0002 (0.0001)	-0.0043 (0.0044)	+0.0001 (0.0002)
Tertile 2 (medium)	-0.0015 (0.0025)	+0.0001 (0.0001)	-0.0044 (0.0043)	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M2: Emotional support				
Tertile 1 (low)	-0.0003 (0.0024)	+0.0001 (0.0001)	-0.0047 (0.0043)	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0019 (0.0024)	+0.0001 (0.0001)	-0.0050 (0.0042)	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M3: Emotional support				
Tertile 1 (low)	-0.0023 (0.0024)	+0.0002 (0.0001)	-0.0047 (0.0043)	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0026 (0.0024)	+0.0001 (0.0001)	-0.0050 (0.0041)	+0.0002 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M4: Emotional support				
Tertile 1 (low)	-0.0025 (0.0024)	+0.0002 (0.0001)	-0.0050 (0.0043)	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0027 (0.0024)	+0.0001 (0.0001)	-0.0057 (0.0042)	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M1: Practical support				
Tertile 1 (low)	-0.0007 (0.0025)	-0.00004 (0.00011)	-0.0094 (0.0047)*	+0.0003 (0.0002)
Tertile 2 (medium)	+0.0028 (0.0023)	-0.00025 (0.00010)*	-0.0051 (0.0050)	+0.0001 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference

M2: Practical support				
Tertile 1 (low)	-0.0048 (0.0024)	-0.00004 (0.00011)	-0.0067 (0.0047)	+0.00032 (0.00020)
Tertile 2 (medium)	+0.0027 (0.0024)	-0.00025 (0.00010)*	-0.0027 (0.0049)	+0.00008 (0.00022)
Tertile 3 (high)	reference	reference	reference	reference
M3: Practical support				
Tertile 1 (low)	-0.0050 (0.0024)*	+0.00004 (0.00011)	-0.0111 (0.0047)*	+0.00033 (0.00021)
Tertile 2 (medium)	+0.0013 (0.0023)	-0.00025 (0.00010)*	-0.0068 (0.0050)	+0.00009 (0.00022)
Tertile 3 (high)	reference	reference	reference	reference
M4: Practical support				
Tertile 1 (low)	-0.0050 (0.0024)*	+0.00005 (0.00010)	-0.0090 (0.0046)	+0.00032 (0.00020)
Tertile 2 (medium)	+0.0013 (0.0023)	-0.00025 (0.00010)*	-0.0046 (0.0049)	+0.00008 (0.00022)
Tertile 3 (high)	reference	reference	reference	reference
M1: Negative aspects				
Tertile 1 (low)	-0.0048 (0.0025)*	-0.00027 (0.00011)*	-0.0115 (0.0044)**	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0081 (0.0025)**	-0.00003 (0.00011)	-0.0102 (0.0044)*	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M2: Negative aspects				
Tertile 1 (low)	-0.0031 (0.0025)	-0.00027 (0.00011)*	-0.0096 (0.0043)*	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0067 (0.0024)**	-0.00003 (0.00011)	-0.0091 (0.0044)*	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M3: Negative aspects				
Tertile 1 (low)	-0.0024 (0.0024)	-0.00027 (0.00011)*	-0.0077 (0.0043)	+0.0002 (0.0001)
Tertile 2 (medium)	-0.0060 (0.0024)*	-0.00003 (0.00011)	-0.0086 (0.0043)*	+0.0003 (0.0001)
Tertile 3 (high)	reference	reference	reference	reference

M4: Negative aspects				
Tertile 1 (low)	-0.0022 (0.0024)	-0.00027 (0.00011)*	-0.0084 (0.0044)	+0.0002 (0.0002)
Tertile 2 (medium)	-0.0058 (0.0024)*	-0.00003 (0.00011)	-0.0089 (0.0043)*	+0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M1: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0052 (0.0030)	+0.0004 (0.0001)**	-0.0077 (0.0043)	-0.00006 (0.00019)
Divorced/widowed	+0.0153 (0.0044)**	-0.0004 (0.0002)*	+0.0067 (0.0049)	-0.00041 (0.00021)*
M2: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0083 (0.0030)**	+0.0004 (0.0001)**	-0.0047 (0.0042)	-0.00009 (0.00018)
Divorced/widowed	+0.0139 (0.0043)**	-0.0004 (0.0002)*	+0.0075 (0.0048)	-0.00043 (0.00021)*
M3: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0104 (0.0031)**	+0.0004 (0.0001)**	-0.0030 (0.0042)	-0.00007 (0.00019)
Divorced/widowed	+0.0086 (0.0045)*	-0.0004 (0.0002)*	+0.0060 (0.0048)	-0.00043 (0.00021)*
M4: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0105 (0.0031)**	+0.0004 (0.0001)**	-0.0030 (0.0042)	-0.00007 (0.00019)
Divorced/widowed	+0.0084 (0.0045)	-0.0004 (0.0002)*	+0.0061 (0.0048)	-0.00043 (0.00021)*

* <0.05; ** p<0.01; **M1: unadjusted model**: age at baseline; **M2**: M1 + ethnicity + employment grade; **M3:** M2 + health behaviours, **M4**: all covariates in M3 + GHQ

Table 43 Trajectories of BMI and WHR by relationship status, complete case analysis of participants who remain in the same relationship status over phases 2-11, n=4,049.

	men n=3,038		**women n=1,011**	
		BMI		
	Intercept coefficient	Linear slope coefficient	Intercept coefficient	Linear slope coefficient
M1: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.42 (0.20)*	+0.024 (0.008)*	+0.04 (0.36)	-0.005 (0.013)
Divorced/widowed	+0.88 (0.39)*	+0.029 (0.015)	+0.40 (0.45)	+0.010 (0.016)
M2: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.53 (0.21)*	+0.024 (0.008)**	+0.10 (0.36)	-0.005 (0.013)
Divorced/widowed	+0.75 (0.39)	+0.029 (0.015)	+0.31 (0.44)	+0.010 (0.016)
M3: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.50 (0.20)*	+0.024 (0.008)**	+0.03 (0.36)	-0.004 (0.013)
Divorced/widowed	+0.52 (0.38)	+0.029 (0.015)	+0.19 (0.44)	+0.010 (0.016)
M4: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.49 (0.20)*	+0.024 (0.008)**	+0.03 (0.36)	-0.004 (0.013)
Divorced/widowed	+0.55 (0.38)	+0.029 (0.015)	+0.19 (0.44)	+0.010 (0.016)
		WHR		
M1: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.008 (0.004)*	+0.0005 (0.0002)**	-0.001 (0.005)	-0.0003 (0.0002)
Divorced/widowed	+0.031 (0.008)***	-0.0006 (0.0003)	+0.009 (0.006)	-0.0008 (0.0003)**
M2: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.011 (0.004)**	+0.0005 (0.0002)**	+0.002 (0.005)	-0.0003 (0.0002)
Divorced/widowed	+0.027 (0.008)***	-0.0006 (0.0003)	+0.009 (0.006)	-0.0008 (0.0003)**
M3: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.011 (0.004)**	+0.0005 (0.0002)**	+0.002 (0.005)	-0.0004 (0.0002)
Divorced/widowed	+0.019 (0.008)*	-0.0006 (0.0003)	+0.007 (0.007)	-0.0008 (0.0003)**
M4: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.011 (0.004)**	+0.0005 (0.0002)**	+0.002 (0.005)	-0.0004 (0.0002)
Divorced/widowed	+0.019 (0.008)**	-0.0006 (0.0003)	+0.007 (0.006)	-0.0008 (0.0003)**

* p<0.05; ** p<0.01, *** p<0.001

Appendix IV: Longitudinal analysis of the imputed data

Table 44 Characteristics of participants included in the longitudinal analysis (imputed sample, n=6,238)

	Total	**Men**	**Women**
	N (%)	**N (%)**	**N (%)**
Gender	----	70.7	29.3
Baseline age [**mean (SD)]**	47.49 (5.99)	47.31 (5.98)	47.94 (5.99)†
Ethnicity			
White British **(ref)**	92.5	94.0	88.6
South Asian	4.6	4.2	5.5 *
Black African & Caribbean	2.2	1.2	4.6 †
Other	0.8	0.1	1.3 **
Employment grade			
Administrative **(ref)**	38.4	47.2	16.9
Professional/executive	47.7	47.5	48.2 †
Clerical/support	13.9	5.3	34.9 †
Longstanding illness			
Yes **(ref)**	35.4	35.0	36.4
No	64.6	65.0	63.6
Smoking status			
Never-smoker **(ref)**	51.3	49.2	56.6
Ex-smoker	36.3	39.7	27.8 †
Current smoker	12.4	11.1	15.6 *
Freq. of fruit & veg intake			
Less than daily **(ref)**	39.6	42.1	33.7
Daily and more	60.4	57.9	66.3 †
Freq. of mild exercise			
>3/week **(ref)**	67.7	69.6	63.0
1-2/week	24.5	23.0	28.2 †
1-3/month & seldom	7.8	7.4	8.8 **
Freq. of moderate exercise			
>3/week **(ref)**	13.8	14.8	11.2
1-2/week	41.7	43.8	36.6
1-3/month	32.5	32.7	32.0 **
Seldom	12.0	8.7	20.2 †
Freq. of vigorous exercise			
1-3/week **(ref)**	21.0	24.9	11.6
1-3/month	20.0	22.9	12.8 *
Seldom	59.0	52.2	75.6 †
GHQ score			

< 4	69.6	71.9	64.1
≥ 5	30.4	28.1	35.9 †
Alcohol intake			
Low <14/21 units	84.8	82.2	91.0
High >14/21 units	15.2	17.8	9.0 †
Emotional support			
Tertile 1 (low)	35.0	36.2	32.2
Tertile 2	33.0	30.9	34.5
Tertile 3 (high, **ref**)	33.0	32.9	33.3
Practical support			
Tertile 1 (low)	37.4	33.6	46.4 †
Tertile 2	35.2	35.8	33.8 †
Tertile 3 (high, **ref**)	27.4	30.6	19.8
Negative interactions			
Tertile (low)	35.8	35.3	37.0
Tertile 2	35.9	36.4	34.5
Tertile 3 (high, **ref**)	28.3	28.3	28.5
Relationship status			
Married/cohabiting **(ref)**	77.3	83.8	61.4
Single	14.5	11.3	22.4 †
Divorced/widowed	8.2	4.9	16.2 †

Table 45 Trajectories of BMI by social support over phases 3 (1991-1994) – 11 (2012-2013), imputed sample, n=6,238

	BMI: men, n=4,408			**BMI: women, N=**1,830		
Model	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient	Intercept coefficient	Linear slope coefficient	Nonlinear change coefficient
M1: Emotional support						
Tertile 1 (low)	-0.185 (0.128)	+0.029 (0.011) *	-0.0012 (0.0004) **	-0.229 (0.302)	0.048 (0.025)	-0.0018 (0.0009)
Tertile 2 (medium)	-0.130 (0.129)	+0.029 (0.012) *	-0.0011 (0.0004) *	-0.078 (0.292)	0.066 (0.024) **	-0.0019 (0.0009) *
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M2: Emotional support						
Tertile 1 (low)	-0.202 (0.129)	+0.029 (0.011) *	-0.0012 (0.0004) **	-0.278 (0.298)	0.048 (0.025)	-0.0018 (0.0009)
Tertile 2 (medium)	-0.133 (0.129)	+0.029 (0.012) *	-0.0011 (0.0004) *	-0.113 (0.288)	0.066 (0.024) **	-0.0019 (0.0009) *
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M3: Emotional support						
Tertile 1 (low)	-0.280 (0.127)	+0.029 (0.011) *	-0.0012 (0.0004) **	-0.354 (0.296)	0.048 (0.025)	-0.0018 (0.0009)
Tertile 2 (medium)	-0.153 (0.127)	+0.029 (0.012) *	-0.0011 (0.0004) *	-0.159 (0.285)	0.065 (0.024) **	-0.0019 (0.0009) *
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Emotional support						
Tertile 1 (low)	-0.273 (0.127) *	+0.029 (0.011) *	-0.0012 (0.0004) **	-0.361 (0.296)	0.048 (0.025)	-0.0018 (0.0009)
Tertile 2 (medium)	-0.150 (0.127)	+0.029 (0.012) *	-0.0011 (0.0004) *	-0.170 (0.285)	0.066 (0.024) **	-0.0019 (0.0009) *
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Practical support						
Tertile 1 (low)	-0.082 (0.129)	-0.011 (0.011)	+0.0001 (0.0004)	-0.845 (0.321) **	+0.005 (0.029)	-0.0003 (0.0011)
Tertile 2 (medium)	-0.032 (0.126)	+0.004 (0.011)	-0.0006 (0.0004)	-0.930 (0.337) **	+0.036 (0.028)	-0.0017 (0.0011)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference

M2: Practical support						
Tertile 1 (low)	-0.119 (0.129)	-0.011 (0.011)	+0.0001 (0.0004)	-0.769 (0.317) *	+0.005 (0.028)	-0.0003 (0.0011)
Tertile 2 (medium)	-0.036 (0.126)	+0.004 (0.011)	-0.0006 (0.0004)	-0.899 (0.332) **	+0.037 (0.028)	-0.0017 (0.0011)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M3: Practical support						
Tertile 1 (low)	-0.243 (0.128)	-0.011 (0.012)	+0.0001 (0.0004)	-0.844 (0.316)**	+0.005 (0.028)	-0.0003 (0.0011)
Tertile 2 (medium)	-0.082 (0.124)	+0.004 (0.011)	-0.0006 (0.0004)	-0.881 (0.330)**	+0.037 (0.028)	-0.0017 (0.0012)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M4: Practical support						
Tertile 1 (low)	-0.237 (0.128)	-0.011 (0.011)	+0.0001 (0.0004)	-0.800 (0.317) *	-0.005 (0.028)	-0.0003 (0.0011)
Tertile 2 (medium)	-0.079 (0.124)	+0.004 (0.011)	-0.0006 (0.0004)	-0.877 (0.330) **	+0.037 (0.028)	-0.0017 (0.0011)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Negative aspects						
Tertile 1 (low)	-0.138 (0.129)	-0.029 (0.011) *	+0.0008 (0.0004)	-0.359 (0.297)	+0.012 (0.030)	-0.0001 (0.0010)
Tertile 2 (medium)	-0.315 (0.128) *	-0.012 (0.012)	+0.0005 (0.0005)	-0.515 (0.301)	+0.052 (0.030) *	-0.0014 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M2: Negative aspects						
Tertile 1 (low)	-0.158(0.130)	-0.029 (0.011) *	+0.0008 (0.0004)	-0.330 (0.295)	0.012 (0.025)	-0.0001 (0.0010)
Tertile 2 (medium)	-0.327 (0.129) *	-0.012 (0.012)	+0.0005 (0.0005)	-0.528 (0.297)	0.051 (0.026) *	-0.0014 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M3: Negative aspects						
Tertile 1 (low)	-0.122 (0.128)	-0.029 (0.011) *	+0.0007 (0.0004)	-0.222 (0.294)	0.012 (0.025)	-0.0001 (0.0010)
Tertile 2 (medium)	-0.311 (0.127) *	-0.012 (0.012)	+0.0005 (0.0005)	-0.568 (0.295)	0.051 (0.026) *	-0.0014 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference

M4: Negative aspects						
Tertile 1 (low)	-0.163 (0.131)	-0.029 (0.011) *	0.0007 (0.0004)	-0.163 (0.300)	0.012 (0.025)	-0.0001 (0.0010)
Tertile 2 (medium)	-0.336 (0.128) **	-0.012 (0.012)	0.0005 (0.0005)	-0.542 (0.296)	0.051 (0.026) *	-0.0014 (0.0010)
Tertile 3 (high)	reference	reference	reference	reference	reference	reference
M1: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.288 (0.155)	+0.020 (0.006)**	----	-0.132 (0.282)	+0.017 (0.010)	----
Divorced/widowed	+0.327 (0.228)	+0.005 (0.009)	----	+0.350 (0.320)	+0.016 (0.012)	----
M2: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.389 (0.157)*	+0.020 (0.006)**	----	-0.025 (0.280)	+0.017 (0.010)	----
Divorced/widowed	0.278 (0.228)	+0.005 (0.009)	----	+0.255 (0.315)	+0.016 (0.012)	----
M3: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.447 (0.156)**	0.020 (0.006)**	----	-0.054 (0.280)	0.017 (0.010)	----
Divorced/widowed	0.098 (0.227)	0.005 (0.009)	----	+0.203 (0.314)	0.016 (0.012)	----
M4: Relationship status						
Married/cohabiting	reference	reference	----	reference	reference	----
Single	-0.444 (0.156)**	0.020 (0.006)**	----	-0.053 (0.280)	+0.017 (0.010)	----
Divorced/widowed	+0.112 (0.228)	0.005 (0.009)	----	+0.189 (0.214)	+0.016 (0.012)	----

* <0.05, ** p<0.01; **M1: unadjusted model**: age at baseline; **M2**: M1 + ethnicity + employment grade; **M3:** M2 + health behaviours, **M4**: all covariates in M3+ GHQ

Table 46 Trajectories of WHR by social support over phases 3 (1991-1994) – 11 (2012-2013), imputed sample, n=6,238

	WHR: men, n=4,408		WHR: women, n=1,830	
Model	Intercept coefficient	Linear slope coefficient	Intercept coefficient	Linear slope coefficient
M1: Emotional support				
Tertile 1 (low)	+0.0003 (0.0024)	+0.0001 (0.0001)	-0.0031 (0.0043)	+0.0001 (0.0002)
Tertile 2 (medium)	-0.0018 (0.0024)	+0.0001 (0.0001)	-0.0030 (0.0041)	+0.0001 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M2: Emotional support				
Tertile 1 (low)	-0.0003 (0.0024)	+0.0001 (0.0001)	-0.0035 (0.0042)	+0.0001 (0.0002)
Tertile 2 (medium)	-0.0021 (0.0024)	+0.0001 (0.0001)	-0.0036 (0.0040)	+0.0001 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M3: Emotional support				
Tertile 1 (low)	-0.0024 (0.0023)	+0.0001 (0.0001)	-0.0040 (0.0042)	+0.0001 (0.0002)
Tertile 2 (medium)	-0.0024 (0.0023)	+0.0001 (0.0001)	-0.0044 (0.0040)	+0.0002 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M4: Emotional support				
Tertile 1 (low)	-0.0026 (0.0023)	+0.0001 (0.0001)	-0.0040 (0.0042)	+0.0001 (0.0002)
Tertile 2 (medium)	-0.0029 (0.0023)	+0.0001 (0.0001)	-0.0044 (0.0040)	+0.0002 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M1: Practical support				
Tertile 1 (low)	-0.0010 (0.0025)	-0.00004 (0.00011)	-0.0087 (0.0045) *	+0.0001 (0.0002)
Tertile 2 (medium)	+0.0020 (0.0023)	-0.00024 (0.00010) *	-0.0034 (0.0048)	-0.0002 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference

M2: Practical support				
Tertile 1 (low)	-0.0010 (0.0024)	-0.00002 (0.00010)	-0.0055 (0.0044)	+0.00018 (0.00020)
Tertile 2 (medium)	+0.0020 (0.0023)	-0.00024 (0.00010) *	-0.0012 (0.0047)	+0.00002 (0.00021)
Tertile 3 (high)	reference	reference	reference	reference
M3: Practical support				
Tertile 1 (low)	-0.0051 (0.0024) *	+0.00002 (0.00010)	-0.0076 (0.0043)	+0.00019 (0.00020)
Tertile 2 (medium)	+0.0007 (0.0023)	-0.00024 (0.00010) *	-0.0026 (0.0046)	-0.00002 (0.00021)
Tertile 3 (high)	reference	reference	reference	reference
M4: Practical support				
Tertile 1 (low)	-0.0051 (0.0024) *	0.00002 (0.00010)	-0.0073 (0.0044)	+0.00019 (0.00020)
Tertile 2 (medium)	+0.0008 (0.0023)	-0.00024 (0.00010) *	-0.0027 (0.0046)	+0.00002 (0.00021)
Tertile 3 (high)	reference	reference	reference	reference
M1: Negative aspects				
Tertile 1 (low)	-0.0047 (0.0024) *	-0.00025 (0.00010) *	-0.0131 (0.0042) **	0.0002 (0.0002)
Tertile 2 (medium)	-0.0082 (0.0024) **	-0.00002 (0.00010)	-0.0100 (0.0042) *	0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M2: Negative aspects				
Tertile 1 (low)	-0.0029 (0.0024)	-0.00025 (0.00010)*	-0.0101 (0.0041) *	0.0002 (0.0002)
Tertile 2 (medium)	-0.0068 (0.0024) **	-0.00002 (0.00010)	-0.0084 (0.0041) *	0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M3: Negative aspects				
Tertile 1 (low)	-0.0020 (0.0023)	-0.00025 (0.00010) *	-0.0085 (0.0041) *	0.0002 (0.0002)
Tertile 2 (medium)	-0.0060 (0.0023) **	-0.00002 (0.00010)	-0.0083 (0.0041) *	0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference

M4: Negative aspects				
Tertile 1 (low)	-0.0018 (0.0024)	-0.00025 (0.00010) *	-0.0088 (0.0042) *	0.0002 (0.0002)
Tertile 2 (medium)	-0.0059 (0.0023) *	-0.00002 (0.00010)	-0.0085 (0.0041) *	0.0003 (0.0002)
Tertile 3 (high)	reference	reference	reference	reference
M1: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0034 (0.0031)	+0.0004 (0.0001) **	-0.0091 (0.0041)	-0.00002 (0.00018)
Divorced/widowed	+0.0118 (0.0044) **	-0.0004 (0.0002) *	+0.0074 (0.0047)	-0.00050 (0.00021) *
M2: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0065 (0.0031) *	+0.0004 (0.0001) **	-0.0054 (0.0041)	-0.00002 (0.0002)
Divorced/widowed	+0.0106 (0.0044) *	-0.0004 (0.0002) *	+0.0080 (0.0046)	-0.00050 (0.00021) *
M3: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.008 (0.0030) **	+0.0004 (0.0001) **	-0.0042 (0.0041)	-0.00002 (0.00018)
Divorced/widowed	+0.0058 (0.0043)	-0.0004 (0.0002) *	+0.0070 (0.0046)	-0.00050 (0.00021) *
M4: Relationship status				
Married/cohabiting	reference	reference	reference	reference
Single	-0.0083 (0.0030) **	+0.0004 (0.0001) **	-0.0042 (0.0041)	-0.00002 (0.00018)
Divorced/widowed	+0.0055 (0.0043)	-0.0004 (0.0002) *	+0.0070 (0.0046)	-0.00050 (0.00021)*

* <0.05, ** p<0.01; **M1: unadjusted model**: age at baseline; **M2**: M1 + ethnicity + employment grade; **M3:** M2 + health behaviours, **M4**: all covariates in M3+ GHQ

Appendix V: Social support questionnaire completed by the bariatric surgery patients

University College London Hospitals NHS
NHS Foundation Trust

Date..... Participant ID.....

***Part 1**: This section asks about your education and employment status.*

1.1. What is the highest educational or school qualification you have obtained?

- ☐ CSE
- ☐ GCSE/O Level
- ☐ Standard/Ordinary (O) Grade / Lower (Scotland)
- ☐ Other school (inc. school leaving exam certificate or matriculation)
- ☐ AS Level
- ☐ A Level
- ☐ Certificate of sixth year studies
- ☐ Higher Grade/Advanced Higher (Scotland)
- ☐ International Baccalaureate
- ☐ Welsh Baccalaureate
- ☐ Nursing or other qualification allied to medicine
- ☐ Teaching qualification (excluding PGCE)
- ☐ Diploma in higher education
- ☐ First degree level qualification inc. foundation degrees, graduate membership of a professional Institute, PGCE
- ☐ University Higher Degree (e.g. MSc, PhD)
- ☐ None of the above

1.2. Are you currently in paid employment?

- ☐ Yes
- ☐ No

***Part 2**: This section asks about your relationships with other people.*

2.1. What is your current marital status? Tick all that apply.

- ☐ Single (never married) → go to **2.3.**
- ☐ Married; in civil partnership or cohabiting → go to **2.2.**
- ☐ Separated or Divorced → go to **2.3.**
- ☐ Widowed → go to **2.3.**

2.2. All things considered how satisfied or dissatisfied are you with your marriage or partnership?

Very dissatisfied	Moderately dissatisfied	A Little dissatisfied	No feelings either way	A little satisfied	Moderately satisfied	Very satisfied
☐	☐	☐	☐	☐	☐	☐

2.3. Who have you felt closest to in the last 12 months? Please describe in terms of their relationship to you and **tick one**:

- ☐ Partner/Spouse/ Boyfriend/Girlfriend
- ☐ Friend
- ☐ Sibling
- ☐ Parent
- ☐ Child
- ☐ Other relative or acquaintance

2.4. All things considered how satisfied or dissatisfied are you with your relationship with the closest person?

Very dissatisfied	Moderately dissatisfied	A Little dissatisfied	No feelings either way	A little satisfied	Moderately satisfied	Very satisfied
☐	☐	☐	☐	☐	☐	☐

2.5. Thinking about the person you are closest to, please tell us how you would rate the practical and emotional support they have provided for you in the last 12 months.

	How much in the last 12 months…	Not at all	A little	Quite a lot	A great deal
1.	Did this person give you information, suggestions and guidance that you found helpful?	☐	☐	☐	☐
2.	Could you rely on this person (was this person there when you needed him/her?)	☐	☐	☐	☐
3.	Did this person make you feel good about yourself?	☐	☐	☐	☐
4.	Did you share interests, hobbies and fun with this person?	☐	☐	☐	☐
5.	Did this person give you worries, problems and stress?	☐	☐	☐	☐
6.	Did you want to confide in (talk frankly, share feelings with) this person?	☐	☐	☐	☐
7.	Did you confide in this person?	☐	☐	☐	☐
8.	Did you trust this person with your most personal worries and problems?	☐	☐	☐	☐
9.	Would you have liked to have confided more in this person?	☐	☐	☐	☐
10.	Did talking to this person make things worse?	☐	☐	☐	☐
11.	Did he/she talk about his personal problems with you?	☐	☐	☐	☐
12.	Did you need practical help from this person with major things? (e.g. look after you when ill, help with finances, children)?	☐	☐	☐	☐
13.	Did the person give you practical help with major things?	☐	☐	☐	☐
14.	Would you have liked more practical help with major things from this person?	☐	☐	☐	☐
15.	Did this person give you practical help with small things when you needed it? (e.g. chores, shopping, watering plants)	☐	☐	☐	☐

2.6. How many relatives do you see once a month or more?

☐ None ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ More than 10

2.7. How many friends and acquaintances do you see once a month or more?

☐ None ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ More than 10

2.8. Think for a moment about relationships you have had with your friends, neighbours, and relatives. Please answer:

In the last 12 months how often have you...	Very Often	Fairly Often	Once in A while	Never
1. Provided someone with some transportation?	☐	☐	☐	☐
2. Pitched in to help someone do something that needed to get done, like household chores or DIY?	☐	☐	☐	☐
3. Helped someone with their shopping?	☐	☐	☐	☐
4. Told someone what you did in a stressful situation that was similar to one they were experiencing?	☐	☐	☐	☐
5. Suggested some action that someone should take in order to deal with a problem they were having?	☐	☐	☐	☐
6. Given someone information that made a difficult situation clearer and easier to understand?	☐	☐	☐	☐
7. Comforted someone by showing them physical affection?	☐	☐	☐	☐
8. Listened to someone talk about their private feelings?	☐	☐	☐	☐
9. Expressed interest and concern in someone's well-being?	☐	☐	☐	☐
10. Been right there with someone who was experiencing a stressful situation?	☐	☐	☐	☐

2.9. Think about your answers in question **2.8.**, who were these people for whom you did above-mentioned things? Tick all that apply.

☐ Partner/Spouse Boyfriend/Girlfriend ☐ Friend ☐ Sibling ☐ Parent ☐ Child ☐ Other relative or acquaintance

2.10. Do you know someone who has undergone a bariatric (weight-loss) surgery?

☐ Yes → go to **2.11.** ☐ No → go to **Part 3**

2.11. Who is this person in relation to you?

☐ Partner/Spouse Boyfriend/Girlfriend ☐ Friend ☐ Sibling ☐ Parent ☐ Child ☐ Other relative or acquaintance

Part 3: *The following are statements that people use to describe themselves. Think about how well the following statements describe you. Please tick one box in each row that best describes how strongly you agree or disagree with the statement.*

	Strongly agree	Agree	Disagree	Strongly disagree
1. I feel that I am a person of worth, at least on an equal plane with others	☐	☐	☐	☐
2. I feel that I have a number of good qualities	☐	☐	☐	☐
3. All in all, I am inclined to feel that I am a failure	☐	☐	☐	☐
4. I am able to do things as well as most other people	☐	☐	☐	☐
5. I feel I do not have much to be proud of	☐	☐	☐	☐
6. I take a positive attitude toward myself	☐	☐	☐	☐
7. On the whole, I am satisfied with myself	☐	☐	☐	☐
8. I wish I could have more respect for myself	☐	☐	☐	☐
9. I certainly feel useless at times	☐	☐	☐	☐
10. At times I think I am no good at all	☐	☐	☐	☐

	Strongly agree	Agree	Disagree	Strongly disagree
1. I can do just about anything I really set my mind to do	☐	☐	☐	☐
2. What happens to me in the future mostly depends on me	☐	☐	☐	☐
3. There is really no way I can solve some of the problems I have	☐	☐	☐	☐
4. Sometimes I feel that I'm being pushed around in life	☐	☐	☐	☐
5. I have little control over the things that happen to me	☐	☐	☐	☐
6. I often feel helpless in dealing with the problems of life	☐	☐	☐	☐
7. There is little I can do to change many of the important things in my life	☐	☐	☐	☐

☐

Thank you!

Appendix VI: Ethical approval for the inclusion of the social support questionnaire

NHS
Health Research Authority

NRES Committee London - Harrow
Level 3, Block B
Whitefriars
Lewins Mead
Bristol
BS1 2NT
Tel: 0117 342 1384

17 October 2014

Dr Rachel Batterham
University College London
Centre for Obesity Research
Department of Medicine
Rayne Building
5 University Street
London
WC1E 6JJ

Dear Dr Batterham

Study title:	**Evaluation the impact of carrier status of obesity-linked genetic variants on the outcome of medical weight loss and bariatric surgery**
REC reference:	**09/H0715/65**
Amendment number:	**version 5**
Amendment date:	**30 September 2014**
IRAS project ID:	**24418**

The above amendment was reviewed by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

The Committee requested clarification whether the current mechanisms for follow up will be changed in any way under the new timescales. The Committee also requested minor changes to the PIS to include more detail regarding the questionnaires.

Approved documents

The documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Covering letter on headed paper		30 September 2014
Covering letter on headed paper		12 October 2014
Notice of Substantial Amendment (non-CTIMP)	version 5	30 September 2014
Other [Power of Food Questionnaire]		12 October 2014
Participant information sheet (PIS) [Meal Studies]	5.1	30 September 2014
Participant information sheet (PIS)	5.2	12 October 2014
Research protocol or project proposal	3.1	30 September 2014
Validated questionnaire [Smell & Taste]		
Validated questionnaire [Social Relationship]		
Validated questionnaire [Physical Activity]		

NHS
Health Research Authority

Membership of the Committee

The members of the Committee who took part in the review are listed on the attached sheet.

R&D approval

All investigators and research collaborators in the NHS should notify the R&D office for the relevant NHS care organisation of this amendment and check whether it affects R&D approval of the research.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

We are pleased to welcome researchers and R & D staff at our NRES committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

09/H0715/65:	Please quote this number on all correspondence

Yours sincerely

[redacted]

Miss Shelly Glaister-Young
Alternate Vice-Chair

E-mail: nrescommittee.london-harrow@nhs.net

Enclosures: *List of names and professions of members who took part in the review*

Copy to: *Mr Philip Diamond, Research and Development Directorate, UCLH Foundation Trust*

NRES Committee London - Harrow

Attendance at Sub-Committee of the REC meeting by correspondence

Committee Members:

Name	*Profession*	*Present*
Miss Shelly Glaister-Young - Chair	Barrister (Alternate Vice-Chair)	Yes
Ms Ann Malkin	Consultant Psychologist	Yes

Appendix VII: Information sheet and consent form given to bariatric surgery patients

University College London Hospitals NHS
NHS Foundation Trust

Centre for Obesity Research
University College London
Rayne Institute
London WC1E 6JJ
☎ 02076790991
Fax 02076796583
Email:
andrea.pucci@ucl.ac.uk
Jason.Cheung@uclh.nhs.uk

Information Sheet for Research Participants

CONFIDENTIAL

You will be given a copy of this Information Sheet and a signed copy of your consent form to keep, should you decide to participate in the study.

Study title: THE IMPACT OF GENOTYPE ON THE OUTCOME OF OBESITY TREATMENT.

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?

Obesity is one of the major health problems of the 21st century. Currently, worldwide more than 1.7 billion people are overweight and 310 million are obese. Weight gain occurs when energy intake (calories eaten) is greater than energy expended (calories used). Environmental and lifestyle factors are important risk factors for the development of obesity. In addition, the finding that being overweight tends to run in families suggests that changes in DNA make-up (genes) predispose some people to becoming overweight and obese.

Being overweight or obese is associated with several diseases such as type 2 diabetes, raised blood pressure and heart disease. Weight loss improves these diseases and results in people living for longer. Current methods of getting people to lose weight include diets, tablets and weight-loss (bariatric) surgery. However, patients respond differently to these treatments with some patients losing a large amount of weight and others

losing less. This variability in weight loss may also be due to differences in genes. An understanding of how changes in genes affect weight loss will help us gain better knowledge of how body weight is regulated and help us develop new treatments for obesity.

We plan to look at the genetic make up of patients attending the obesity and bariatric clinics at UCLH and to examine how variations in DNA affect weight loss achieved with diet, tablets or different types of bariatric operations.

Why have I been chosen?
All patients attending the bariatric/obesity services at the University College London Hospital will be invited to participate in the study. You should not take part in this study if you have been previously diagnosed with HIV, hepatitis B or hepatitis C.

Do I have to take part?
No, taking part is voluntary. It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What would happen if I decide to take part?
If you are interested in taking part in the study we will arrange to see you in person to ensure that you understand the purpose of the study and to answer any questions you may have. If you are happy to proceed we will ask you to sign a consent form. Any visits related to the study will be arranged to coincide with your normal outpatient appointments. We will collect information that is taken as part of your routine clinical care. We will need to take one additional blood sample or alternatively request you to provide a sample of your saliva so that we can analyse your DNA. We will ask you to complete questionnaires about how physically active you are, your social circumstances and your relationships with food and about food taste and smell. **It will take you approximately 30 minutes to complete all four of these questionnaires.** You will have the opportunity to ask any questions you may have with regard to these. We will also ask your permission to use your samples in future ethically approved research. You will be free to decide whether you wish your samples to be involved with these potential future studies or not.

We might also invite you to take part in additional studies that would involve you eating nothing from 8pm on the night before coming to the hospital. Some of these studies will involve you eating specific meals or drinking glucose, and blood taking. Before taking part in any of these future studies you will be sent detailed information as to the purpose of each of these studies and details of what these involve. You will be free to decide whether you want to be involved with these future studies or not.

What are the possible disadvantages and risks of taking part?
Blood taking can cause slight discomfort and very occasionally may cause localised bruising.

What are the possible benefits of taking part?
Whilst there are no immediate benefits for those participating in the study, it is hoped that a clearer understanding how changes in DNA affect weight loss will help us gain better knowledge of how body weight is regulated with implications on drug development and future anti-obesity treatments.

What if something goes wrong?
In the event of any adverse events occurring as a consequence of your participation in this study, you will be compensated through the University College London Hospitals NHS Trust insurance scheme.

Will my taking part in the study be kept confidential?
All the information you give us will be confidential and used for the purposes of this study only. The data will be collected and stored in accordance with the Data Protection Act 1998 and will be disposed of in a secure manner. The data will be used in a way that will not allow you to be identified individually.

What happens when the research study stops?
Once the study has finished, the results of the study can be made available to you.

What will happen to the results of the research study?
The results are likely to be published in the twelve months following the study. Your confidentiality will be ensured at all times and you will not be identified in any publication. At the end of the study, the results of the study can be made available to you should you wish.

Who has reviewed this study?
This study has been reviewed by the one of UCLH NHS Foundation Trusts Research Ethics Committees.

What do I do now?
Think about the information on this sheet and ask me if you are not sure about anything. If you agree to take part sign the consent form. The consent form will not be used to identify you. It will be filed separately from all other information.

Contact for further information

If you have any further questions about the study contact:
Dr Andrea Pucci, andrea.pucci@ucl.ac.uk
Dr Jason Cheung, Jason.Cheung@uclh.nhs.uk

THANK YOU VERY MUCH FOR YOUR HELP!

University College London Hospitals NHS
NHS Foundation Trust

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Centre Number:
Patient Identification Number for this study:

UCLH Project ID number: **09/H0715/65**
Form version: Version (6.2)

CONSENT FORM

Title of project: ***Evaluation the impact of carrier status of obesity-linked genetic variants on the outcome of medical weight loss and bariatric surgery.***

Name of Principal Investigator: Dr Rachel Batterham

Please initial box

1. I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I confirm that I have had sufficient time to consider whether or not want to be included in the study. ☐
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐
4. I understand that sections of any of my medical notes and data collected during the study may be looked at by responsible individuals from the UCL research team or from regulatory authorities or from the NHS Trust -where it is relevant to my taking part in research. I give permission for these individuals to have access to my records. ☐
5. I agree to take part in the above study. ☐
6. I understand that my blood or saliva sample taken for DNA analysis is viewed as a gift and I give permission for the sample to be stored. ☐
7. Do you give permission for the sample to be used in future research linked to this project? Please circle yes or no as appropriate. [Yes] [No]

Continued on next page/

Centre Number:
Patient Identification Number for this study:

UCLH Project ID number: **09/H0715/65**
Form version: Version (6.2)

CONSENT FORM

Title of project: ***Evaluation the impact of carrier status of obesity-linked genetic variants on the outcome of medical weight loss and bariatric surgery***

Name of Principal investigator: **Dr Rachel Batterham**

Name of patient	Date	Signature
Name of Person taking consent (if different from researcher)	Date	Signature
Researcher (to be contacted if there are any problems)	Date	Signature

Comments or concerns during the study

If you have any comments or concerns you may discuss these with the investigator. If you wish to go further and complain about any aspect of the way you have been approached or treated during the course of the study, you should write or get in touch with the Complaints Manager, UCL hospitals. Please quote the UCLH project number at the top this consent form.

1 form for Patient;
1 to be kept as part of the study documentation,
1 to be kept with hospital notes

Appendix VIII: Linear regression models of the association between covariates and body mass index at each post-operative time point

Table 47 BMI by covariates, on the day of surgery (DOS) n=155, at 4 weeks n=152, at 3 months n=136 and at 6 months n=123.

	DOS			4 weeks			3 months			6 months		
	N	β (SE)	p	N	β (SE)	p	N	β (SE)	p	N	β (SE)	p
Gender: Men	42	44.36 (1.11)		41	43.04 (1.38)		38	38.96 (1.22)		32	35.63 (1.33)	
Women	113	+0.96 (1.30)	0.46	111	+0.68 (1.29)	0.60	98	+0.36 (1.24)	0.78	91	+0.72 (1.39)	0.60
Age	155	-0.09 (0.05)	0.06	152	-0.06 (0.05)	0.25	136	-0.06 (0.05)	0.27	123	-0.08 (0.05)	0.13
Surgery type: RYGB	51	43.84 (1.00)		51	42.51 (1.23)		44	37.65 (1.13)		39	34.84 (1.12)	
SG	104	+1.82 (1.23)	0.14	101	+1.52 (1.19)	0.21	92	+2.25 (1.17)	0.06	84	+2.14 (1.30)	0.10
Ethnicity: White British*	114	45.30 (0.68)		113	43.84 (0.95)		99	39.31 (0.88)		90	36.31 (0.86)	
Non-White ethnicities	27	-1.01 (1.54)	0.52	26	-0.70 (1.51)	0.65	24	-0.04 (1.48**)**	0.98	22	-0.17 (1.61)	0.92
Not stated	14	-0.68 (2.05)	0.74	13	-1.58 (2.04)	0.44	13	-0.74 (1.92)	0.70	11	-0.98 (2.15)	0.65
Education: Below A level	80	45.22 (0.82)		78	43.73 (1.08)		70	39.10 (0.96)		66	36.39 (0.94)	
A level and above	41	-0.82 (1.39)	0.56	41	-0.42 (1.35)	0.75	37	+0.17 (1.32)	0.90	32	-0.93 (1.46)	0.53
First & higher degree	33	+0.20 (1.50)	0.90	32	-0.16 (1.48)	0.92	29	+0.42 (1.44)	0.77	24	+0.15 (1.62)	0.93
Employed: Yes	89	45.35 (0.77)		88	43.78 (1.04)		77	39.79 (0.90)		70	36.45 (0.93)	
No	64	-0.87 (1.18)	0.46	62	-0.55 (1.16)	0.63	57	-1.05 (1.13)	0.36	52	-0.81 (1.23)	0.51
Self-esteem: low <15	31	47.61 (1.27)		31	46.23 (1.36)		27	41.62 (1.30)		24	38.98 (1.43)	
Normal 15-25	102	-2.74 (1.45)	0.06	100	**-2.87 (1.39)**	**0.041**	91	-2.46 (1.39)	0.08	87	**-3.11 (1.52)**	**0.04**
High 25-30	22	**-5.22 (1.97)**	**0.009**	21	**-5.87 (1.91)**	**0.003**	18	**-5.61 (1.92)**	**0.004**	17	**-5.27 (2.08)**	**0.01**
Self-esteem (continuous)	155	**-0.32 (0.10)**	**0.001**	152	**-0.34 (0.09)**	**<0.001**	136	**-0.29 (0.09)**	**0.002**	123	**-0.32 (0.10)**	**0.00**
Mastery (continuous)	155	-0.08 (0.17)	0.64	152	-0.09 (1.16)	0.58	136	-0.18 (0.16)	0.26	123	-0.13 (0.18)	0.48

* + Other White

Appendix IX: Linear regression models of the association between social support and body mass index at each time point

Table 48 Multiply adjusted associations between received social support, provided social support, romantic relationship satisfaction, satisfaction with the closest person, relationship status, number of friends and relatives seen on a monthly basis and BMI on the day of surgery (DOS) n=155, at 4 weeks n=152, at 3 months n=136 and at 6 months n=123. All exposures were entered in separate models.

BODY MASS INDEX

	DOS		**4 weeks**		**3 months**		**6 months**	
	β (SE)	p	β (SE)	p	β (SE)	p	β (SE)	p
M1: Received emotional support	-0.08 (0.15)	0.59	-0.12 (0.15)	0.43	-0.19 (0.14)	0.18	-0.20 (0.15)	0.19
M2: Received emotional support	-0.09 (0.15)	0.56	-0.11 (0.15)	0.44	-0.20 (0.14)	0.16	-0.20 (0.16)	0.19
M3: Received emotional support	0.07 (0.15)	0.64	0.05 (0.15)	0.74	-0.05 (0.15)	0.74	-0.06 (0.16)	0.70
M1: Received practical support	-0.02 (0.23)	0.93	-0.06 (0.22)	0.78	-0.05 (0.23)	0.84	-0.22 (0.25)	0.38
M2: Received practical support	0.02 (0.23)	0.92	-0.04 (0.22)	0.86	-0.01 (0.23)	0.98	-0.20 (0.26)	0.43
M3: Received practical support	0.04 (0.22)	0.84	-0.02 (0.22)	0.91	0.05 (0.22)	0.81	-0.24 (0.25)	0.34
M1: Received negative aspects	0.12 (0.22)	0.58	0.4 (0.21)	0.85	0.01 (0.21)	0.96	-0.002 (0.218)	0.99
M2: Received negative aspects	0.16 (0.22)	0.47	0.08 (0.22)	0.69	0.05 (0.21)	0.82	0.03 (0.23)	0.88
M3: Received negative aspects	0.08 (021)	0.70	0.003 (0.209)	0.98	-0.05 (0.21)	0.80	-0.03 (0.22)	0.89
M1: Providing emotional support	0.05 (0.14)	0.74	0.02 (0.14)	0.88	0.09 (0.14)	0.50	0.05 (0.15)	0.73
M2: Providing emotional support	0.05 (0.14)	0.70	0.04 (0.14)	0.76	-0.09 (0.14)	0.53	0.06 (0.15)	0.70
M3: Providing emotional support	0.02 (0.14)	0.90	0.005 (0.137)	0.96	-0.14 (0.14)	0.30	0.02 (0.15)	0.91

M1: Providing practical support	-0.35 (0.24)	0.14	-0.28 (0.23)	0.22	-0.13 (0.24)	0.56	-0.18 (0.26)	0.48
M2: Providing practical support	-0.35 (0.24)	0.14	-0.28 (0.24)	0.23	-0.13 (0.24)	0.59	-0.19 (0.26)	0.45
M3: Providing practical support	-0.28 (0.23)	0.22	-0.21 (0.23)	0.36	-0.06 (0.23)	0.80	-0.13 (0.25)	0.61
M1: Relationship status								
Married/in civil partnership/cohabiting	51.58 (2.91)		48.47 (3.05)		44.16 (2.81)		40.97 (3.13)	
Single	-2.61 (1.49)	0.08	-2.43 (1.49)	0.10	-2.66 (1.47)	0.07	-1.35 (1.51)	0.37
Divorced/widowed	-0.17 (1.66)	0.91	-0.03 (1.62)	0.98	0.05 (1.58)	0.97	-0.12 (1.82)	0.94
M2: Relationship status								
Married/in civil partnership/cohabiting	51.80 (2.94)		48.59 (3.07)		44.34 (2.85)		41.20 (3.18)	
Single	-2.60 (1.50)	0.08	-2.41 (1.50)	0.11	-2.64 (1.49)	0.07	-1.32 (1.53)	0.39
Divorced/widowed	-0.19 (1.70)	0.90	-0.12 (1.66)	0.94	0.16 (1.62)	0.92	-0.05 (1.89)	0.97
M3: Relationship status								
Married/in civil partnership/cohabiting	59.81 (3.57)		56.65 (3.60)		52.18 (3.40)		48.32 (3.67)	
Single	-2.68 (1.44)	0.06	-2.41 (1.43)	0.09	**-2.96 (1.41)**	**0.039**	-1.40 (1.46)	0.34
Divorced/widowed	+0.64 (1.64)	0.69	0.78 (1.60)	0.62	1.02 (1.55)	0.51	0.95 (1.46)	0.60
M1: Romantic relationship satisfaction								
≤A little satisfied **(ref)**	64.88 (4.54)		60.60 (4.67)		53.86 (4.24)		51.59 (4.33)	
Moderately satisfied	**-8.31 (2.88)**	**0.005**	**-8.12 (2.83)**	**0.005**	**-8.54 (2.75)**	**0.003**	**-11.48 (2.98)**	**<0.00**
Very satisfied	**-8.08 (2.37)**	**0.001**	**-7.64 (2.35)**	**0.002**	**-7.98 (2.16)**	**<0.001**	**-10.48 (2.47)**	**<0.00**
M2: Romantic relationship satisfaction								
≤A little satisfied **(ref)**	65.04 (4.58)		60.62 (4.72)		53.96 (4.34)		52.04 (4.40)	
Moderately satisfied	**-8.50 (2.93)**	**0.005**	**-8.29 (2.88)**	**0.005**	**-8.54 (2.80)**	**0.003**	**-11.88 (3.05)**	**<0.00**
Very satisfied	**-8.02 (2.44)**	**0.001**	**-7.70 (2.40)**	**0.002**	**-8.01 (2.25)**	**0.001**	**-10.83 (2.55)**	**<0.00**

M3: Romantic relationship								
≤A little satisfied **(ref)**	71.34 (5.14)		66.25 (5.20)		59.39 (5.00)		57.58 (.589)	
Moderately satisfied	**-8.38 (2.84)**	**0.004**	**-8.20 (2.80)**	**0.005**	**-8.22 (2.74)**	**0.004**	**-12.13 (2.95)**	**<0.00**
Very satisfied	**-7.19 (2.39)**	**0.004**	**-7.00 (2.36)**	**0.004**	**-7.30 (2.22)**	**0.002**	**-9.86 (2.51)**	**<0.00**
M1: Satisfaction with the closest person								
≤A little satisfied **(ref)**	55.27 (2.99)		51.74 (3.01)		47.70 (2.90)		45.32 (3.23)	
Moderately satisfied	**-6.21 (2.18)**	**0.005**	**-5.90 (2.12)**	**0.006**	**-6.67 (2.12)**	**0.002**	**-5.02 (2.18)**	**0.023**
Very satisfied	**-6.75 (1.85)**	**<0.001**	**-6.53 (1.80)**	**<0.001**	**-6.26 (1.77)**	**0.001**	**-6.09 (1.87)**	**0.001**
M2: Satisfaction with the closest person								
≤A little satisfied **(ref)**	55.68 (3.03)		52.18 (3.04)		48.25 (2.96)		45.96 (3.28)	
Moderately satisfied	**-6.20 (2.20)**	**0.005**	**-5.98 (2.14)**	**0.006**	**-6.89 (2.15)**	**0.002**	**-5.17 (2.21)**	**0.021**
Very satisfied	**-6.90 (1.87)**	**<0.001**	**-6.83 (1.82)**	**<0.001**	**-6.63 (1.81)**	**<0.001**	**-6.42 (1.91)**	**0.001**
M3: Satisfaction with the closest person								
≤A little satisfied **(ref)**	61.13 (3.45)		57.81 (3.40)		53.07 (3.29)		50.92 (3.59)	
Moderately satisfied	**-5.52 (2.15)**	**0.011**	**-5.28 (2.08)**	**0.012**	**-6.18 (2.10)**	**0.004**	**-4.59 (2.14)**	**0.034**
Very satisfied	**-5.94 (1.85)**	**0.002**	**-5.86 (1.79)**	**0.001**	**-5.55 (1.79)**	**0.002**	**-5.58 (1.86)**	**0.003**
M1: Seeing friends/month								
None (**ref**)	44.41 (3.58)		41.96 (3.58)		39.43 (3.41)		34.78 (3.95)	
1-5	**+5.09 (2.51)**	**0.044**	+4.20 (2.45)	0.08	+2.93 (2.29)	0.20	+5.75 (3.18)	0.07
6+	+3.86 (2.54)	0.13	+3.25 (2.49)	0.19	+1.70 (2.34)	0.47	+5.64 (3.24)	0.08
M2: Seeing friends/month								
None (**ref**)	45.00 (3.65)		42.24 (3.65)		39.87 (3.47)		35.13 (4.05)	
1-5	+4.83 (2.54)	0.06	+4.09 (2.49)	0.10	+2.72 (2.33)	0.24	+5.63 (3.25)	0.08
6+	+3.44 (2.61)	0.19	+3.13 (2.56)	0.22	+ 1.37 (2.41)	0.57	+5.45 (3.35)	0.10

M3: Seeing friends/month								
None (**ref**)	51.72 (3.93)		49.06 (3.89)		45.87 (3.71)		41.72 (4.33)	
1-5	**+5.66 (2.45)**	**0.022**	**+4.90 (2.38)**	**0.042**	+3.47 (2.23)	0.12	+5.56 (3.10)	0.07
6+	+4.56 (2.52)	0.07	+4.31 (2.46)	0.08	+2.52 (2.33)	0.28	+5.58 (3.20)	0.08
M1: Seeing relatives/month								
None (**ref**)	48.47 (3.48)		45.20 (3.46)		41.52 (3.31)		37.59 (3.87)	
1-5	+0.55 (2.34)	0.81	+0.67 (2.29)	0.77	+0.25 (2.14)	0.90	+2.13 (2.54)	0.40
6+	+0.52 (2.36)	0.82	+0.40 (2.30)	0.86	+0.38 (2.16)	0.86	+2.07 (2.55)	0.41
M2: Seeing relatives/month								
None (**ref**)	48.64 (3.52)		45.24 (3.50)		41.44 (2.36)		37.56 (3.91)	
1-5	+0.63 (2.38)	0.79	+0.81 (2.33)	0.72	+0.48 (2.18)	0.82	+2.44 (2.59)	0.34
6+	+0.57 (2.40)	0.81	+0.51 (2.34)	0.82	+0.61 (2.20)	0.78	+2.26 (2.60)	0.38
M3: Seeing relatives/month								
None (**ref**)	55.91 (3.95)		52.55 (3.88)		48.12 (3.72)		44.44 (4.28)	
1-5	+0.75 (2.29)	0.74	+0.96 (2.23)	0.66	+0.59 (2.09)	0.77	+2.13 (2.48)	0.39
6+	+1.21 (2.31)	0.60	+1.14 (2.24)	0.61	+1.15 (2.11)	0.58	+2.36 (2.49)	0.35

The End